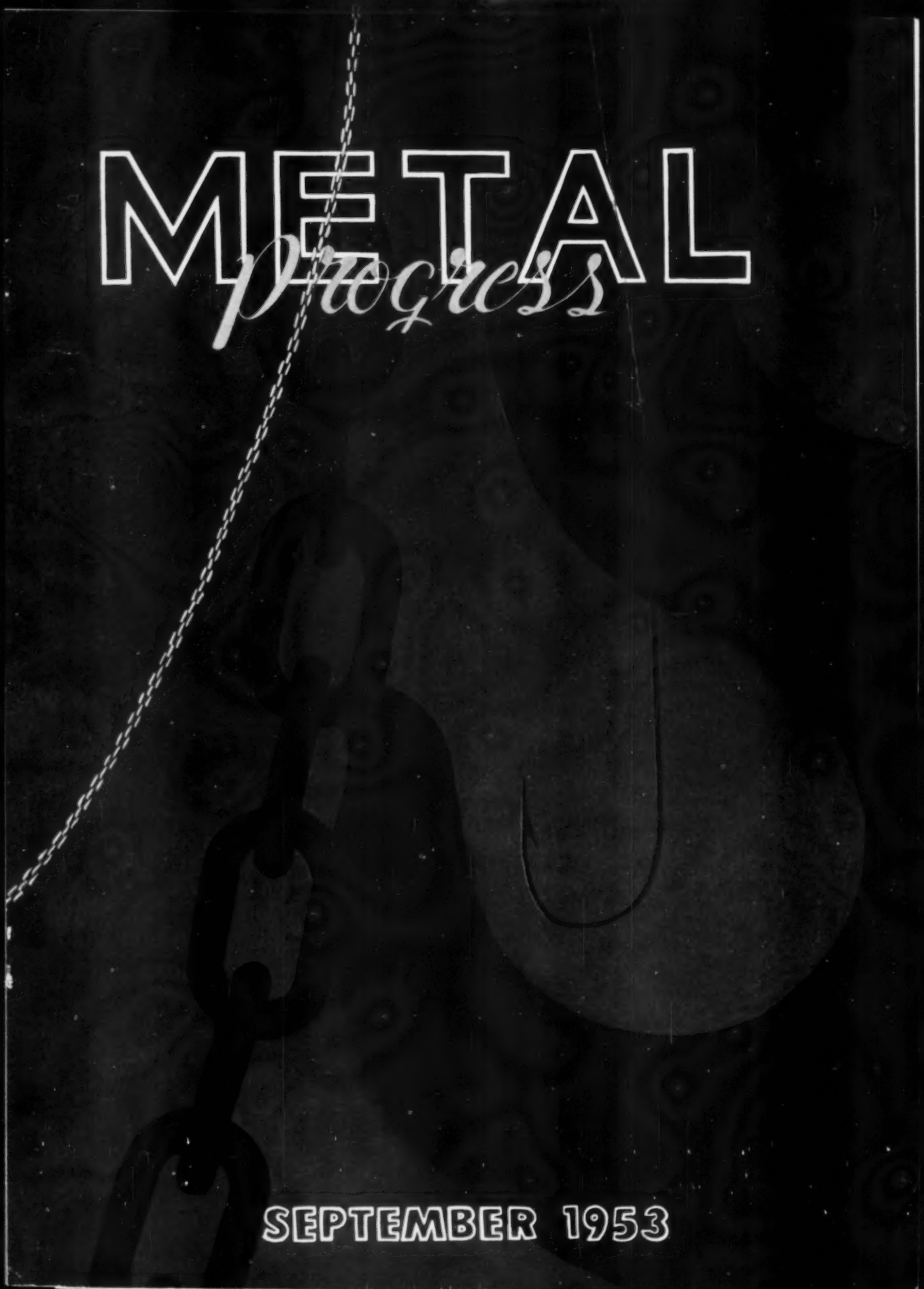
METAL Progress

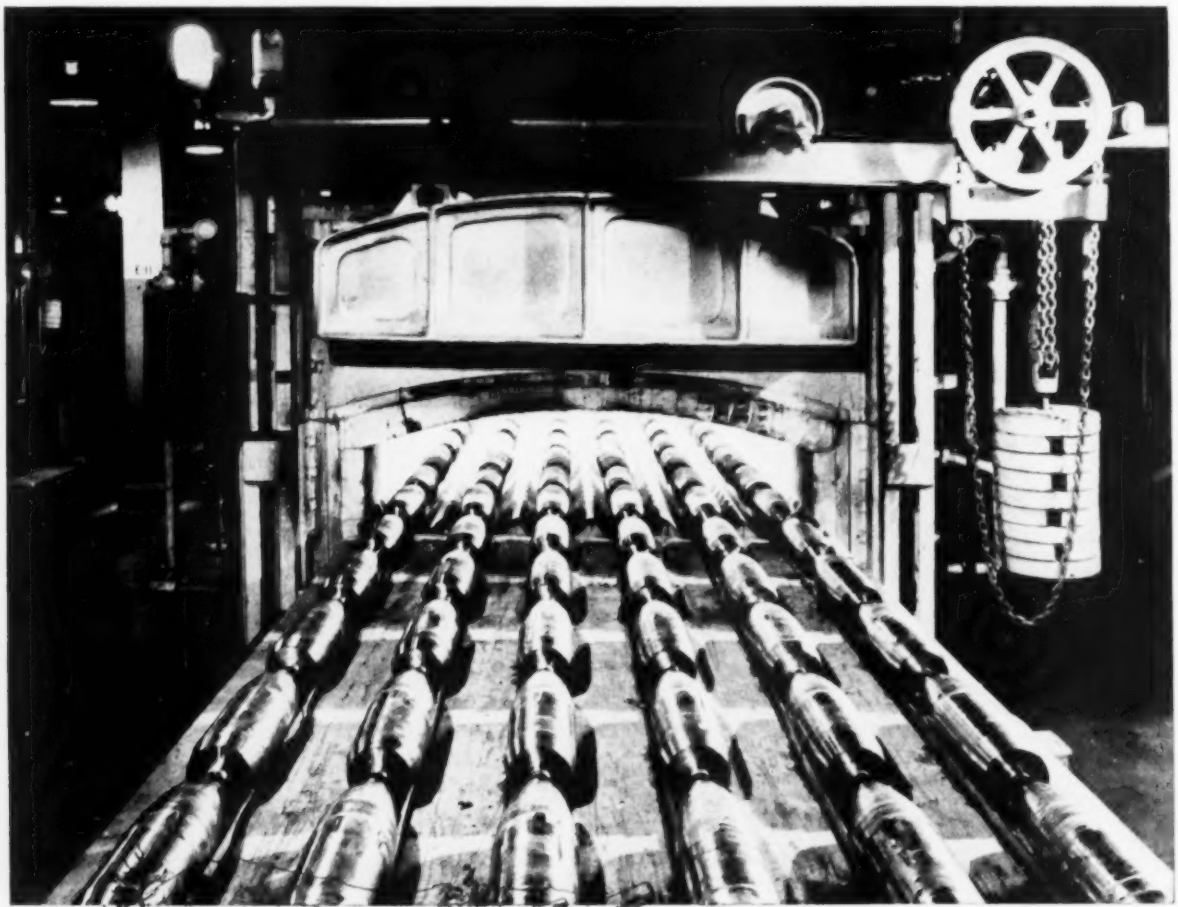


SEPTEMBER 1953

they "pass the ammunition"

When heat treat specifications get really tough—as in the production of projectiles—'Surface' furnaces and conveyor equipment give you the performance you need. The shells pictured are starting through synchronized 'Surface' hardening and drawing furnaces, at 150 rounds or 4200 pounds per hour. This is typical of the many critical jobs being successfully handled by 'Surface' continuous, automatic hardening and drawing lines. They are designed and built to meet *your* production requirements, whether for watch gears, ordnance or auto parts. With 40 years' experience in heat treating, producing many types and sizes of furnaces, with a variety of work handling systems, Surface Combustion can meet your space and production requirements—meet your toughest specifications economically.

Write for Literature Group H53-4.



Surface
HEAT TREATING EQUIPMENT

SURFACE COMBUSTION CORPORATION • TOLEDO 1, OHIO

ALSO MAKERS OF

Kathabar HUMIDITY CONDITIONING *Janitrol* AUTOMATIC SPACE HEATING

IN THIS ISSUE

First prize in the annual *Metal Progress* Cover Competition at Cleveland Institute of Art was awarded for a book and chain design by Carlos Vasquez

Testing Methods

A method for measuring sensitivity to quench cracking 67
Fatigue tests of wire and springs 77
Use of radioactive isotopes 105

Quality Control

An introduction to statistical control 91
Inspection methods at Fairchild aircraft 97
Quality control in copper refining 124

Corrosion

Appraisal of corrosion fundamentals 83
Intergranular corrosion of aluminum 84

Vacuum Metallurgy

Surface protection by vacuum metallizing 87
Commercial vacuum furnaces for melting 161

Phase Relationships

Effect of magnetic field on critical points 110
Occurrence of sigma phase in 25-20 steel 140
The bainite mystery 170

Materials for Industry

Ductile iron for hammer castings 82
A book review of "Boron Steels" 90
Hard, strong titanium alloys 128
Sintered hard metals 132
Iron powder magnets 190

Table of Contents 65
Manufacturers' Literature 23
New Products 9
Advertisers' Index . . . . Last page

• **See** *Bill's Column on the other side* ➡

PERHAPS I shouldn't say it but here goes: The reception the A.S.M. received while touring Europe made me feel just like Ben Hogan being ticker-taped up Broadway.

Early this fall the A.S.M. will receive a formal invitation from the iron and steel institutes and the metallurgical societies of England, Sweden, France and Germany to join with them in holding an International Metallurgical Congress in June 1955. Plans are as follows:

The technical theme of the Congress will be "Steelmaking". The duration is to be three weeks: one week in London, one in Düsseldorf and the last in Paris. Two days in each country will be spent at technical meetings and discussions; the rest of the week will be devoted to visiting plants. At the close of the Congress group visits will be arranged to southern Europe and to the Scandinavian countries. As soon as complete details are available, the entire membership will be notified.

The A.S.M. Publications Committee met in Cleveland in June, reviewed 82 papers and accepted 59, of which 54 have been preprinted (see July *Metals Review*). Of these, 38 will be presented at the Cleveland convention and 16 at the A.S.M. midwinter meeting in Boston's Statler Hotel, March 4 and 5, 1954. Extended digests of many of the Cleveland Convention papers will be published in *Metal Progress* in October and November.

There will be three educational lecture series and a cracker-jack two-day super technical seminar on Saturday and Sunday, Oct. 17 and 18, under the chairmanship of G.E.'s Dave Turnbull. The topic will be "Relation of Properties to Microstructure." An important participant in the seminar will be Alan Cottrell, professor of metallurgy at the University of Birmingham in England. As the Society's guest through the A.S.M. Visiting Lectureship Plan, Dr. Cottrell will present lectures at nine leading educational institutions with top-ranking metallurgical departments.

Letters of commendation have been flooding the headquarters office on the fine series of metals technology lectures presented to vocational teachers under the planning and direction of United Shoe Machinery's Bill Collins, chairman, and his A.S.M. Vocational Educational Committee. The program has been presented to vocational teachers in New York State at Oswego, and in Massachusetts at Fitchburg.

As secretary I have just finished signing my name for the 58,000th time to checks which discharge A.S.M.'s obligations. As secretary of the A.S.M. Foundation for Education and Research, I have signed 45 checks for $400 each and sent them to 45 schools teaching metallurgy. The $400 will be awarded to an individual (preferably a sophomore) selected by the metallurgical department, to assist in defraying his expenses in metallurgical studies.

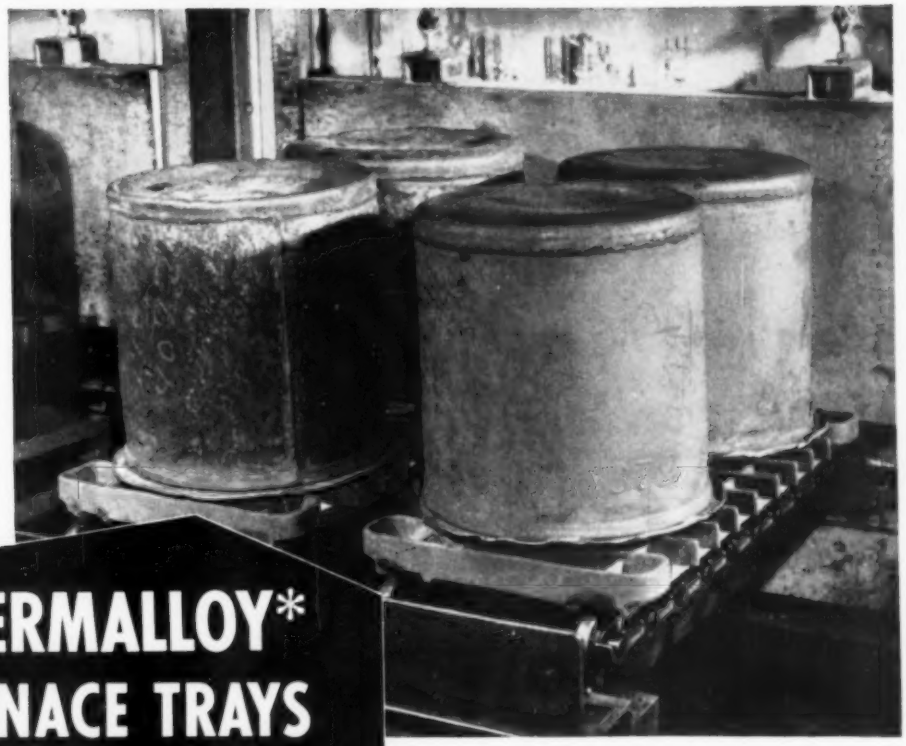
We have just been notified of the names and addresses of 214 winners in the A.S.M. Science Achievement Awards program sponsored by the Society and conducted by the National Science Teachers Association. Checks, Government bonds and certificates will be presented at school assemblies in the fall by representatives of A.S.M. and N.S.T.A. The Science Achievement Award permits the participant to become a member of the Future Scientists of America, and is recognized as a most constructive effort to interest junior high school students in science and senior high school students in engineering as a profession.

I'm looking forward to seeing all of you in Cleveland. Energetic effort on your part to help secure attendance will reward all concerned. Those who have once attended a national convention become regular participants and there is nothing so inspiring and invigorating and so productive of good results as attendance at the annual affair. So come and stay as long as you can. It will be time well spent.

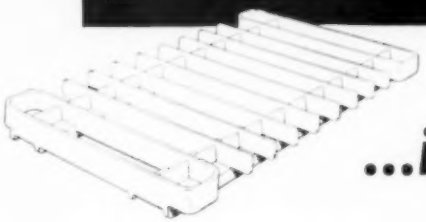
Cordially yours,

Bill

W. H. EISENMAN, *Secretary*
AMERICAN SOCIETY FOR METALS



THERMALLOY* FURNACE TRAYS



...in service over 10,000 hours!

A large automotive parts manufacturer "pack-carburizes" drive pinions in pots conveyed two on a tray through a gas-fired furnace where temperatures range up to 1700°F. Previous designs of the furnace tray cracked, warped and scaled quickly, with average service life limited between 100 and 600 hours.

This manufacturer asked Electro-Alloys engineers how service life of these trays could be extended. Electro-Alloys designed a new furnace tray . . . cast it in a grade of heat-resistant Thermalloy best suited for long carburizing service. Two years ago, these Thermalloy trays were installed. Today, with over 10,000 service hours each, they are still in use.

Thermalloy is not one alloy but a group of alloys—each developed to meet specific high-temperature operating conditions. Electro-Alloys produces many types of high heat-resistant Thermalloy castings such as muffles, retorts, trays, fixtures, baskets, rollers. In many cases too, Electro-Alloys engineers can help you redesign your heat-treating parts in Thermalloy to give more operating hours per dollar. Call your nearest Electro-Alloys representative for full information or write Electro-Alloys Division, 4002 Taylor Street, Elyria, Ohio.

Write for new Thermalloy Tray and Fixture Bulletin T-226.

*Reg. U. S. Pat. Off.

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION
ELYRIA, OHIO

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Thirty five years ago the Spencer Turbo was first specified by a furnace manufacturer. Since that time, the list has grown to more than thirty—all of whom are Spencer users today.

The reasons they prefer Spencer are the absolute reliability — perfect performance and low maintenance over long years of almost continuous service.

Complete information in Bulletin No. 126-A. For other industrial uses, ask for Turbo Date Book No. 107-C.

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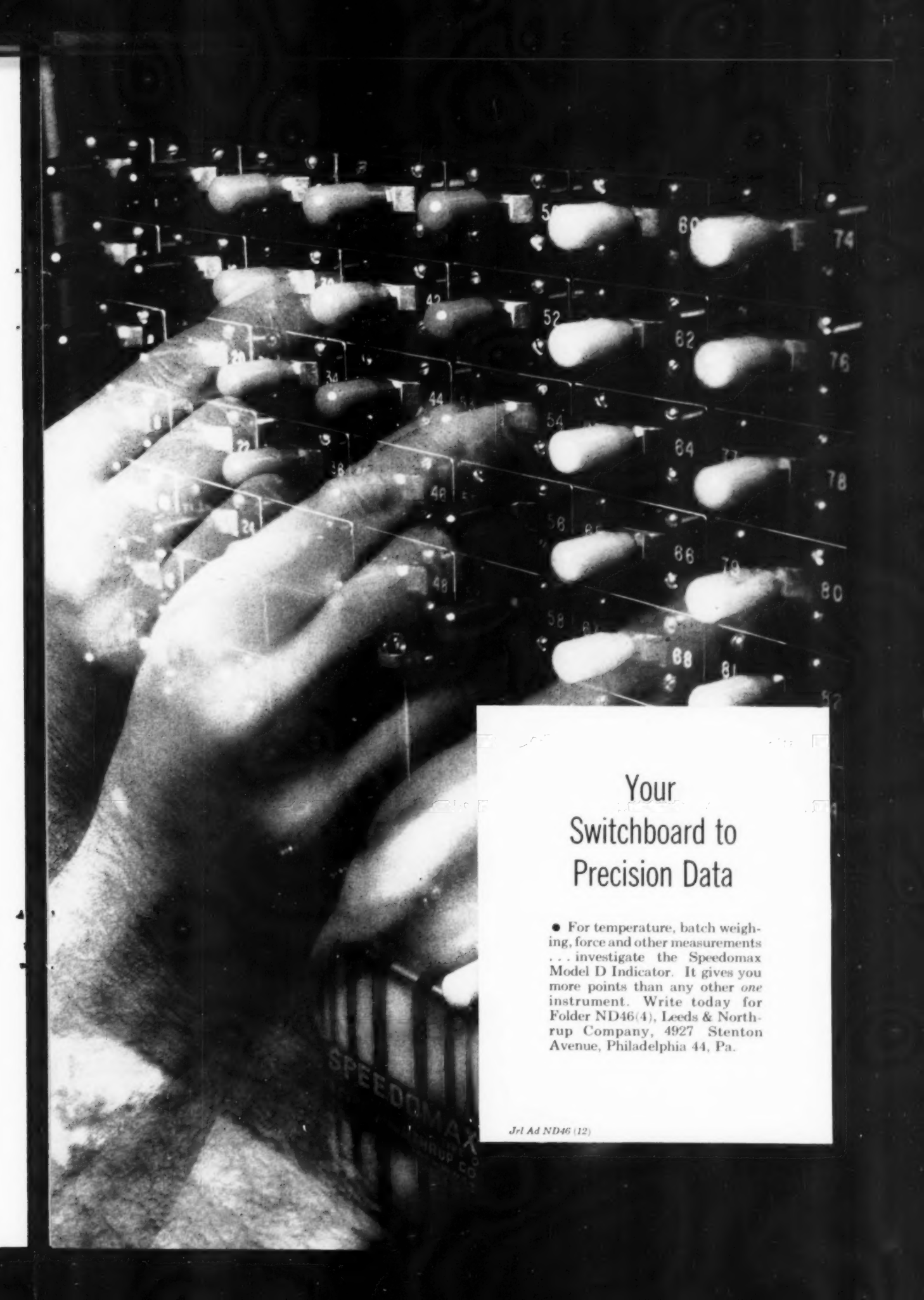

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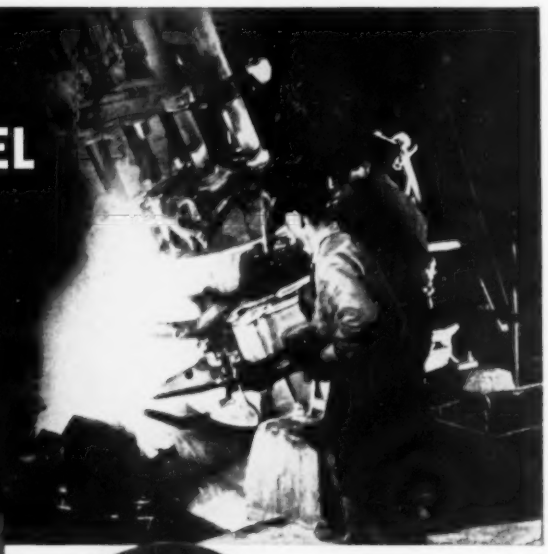
"WAUKESHA METAL" and WAUKESHA STAINLESS STEEL Castings . . . CORROSION TESTED

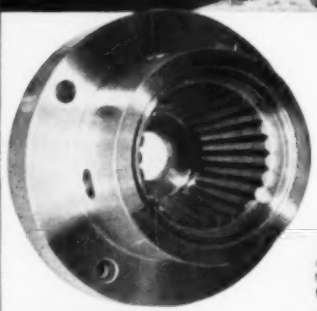
from A (ACETATE SOLVENT) to Z (ZINC CHLORIDE)

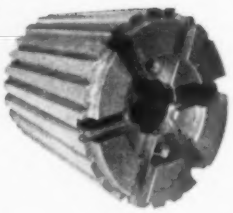


"Waukesha Metal" is a high nickel alloy — close-grained with excellent corrosion-resistant qualities. Waukesha Foundry produces castings in "Waukesha Metals" in a wide range of alloys —

- **for contact with over 100 foods, beverages, chemicals, pharmaceuticals and other products possessing corrosive characteristics.**
- **for bearing applications in equipment requiring sliding or rotational metal-to-metal contact without seizing or galling of corrosion resistant parts.**
- **for free-machining and for high polish surfacing.**

Castings in "WAUKESHA METAL" are so widely used that WAUKESHA is the largest nickel alloy jobbing foundry in the country. As just one example of the industrial acceptance of "WAUKESHA METAL" — virtually all of the milk you drink and all of the ice cream you eat has passed over a "WAUKESHA METAL" casting in processing.





WAUKESHA CASTINGS in Stainless Steel

Available in the 300-400 series . . . in extra low carbon and in the 35-15 and 25-12 high alloy series, WAUKESHA offers Stainless Steel Castings that are produced under strict metallurgical laboratory control for close texture, uniformity and dimensional correctness.

Two Booklets Available

— One booklet on physical properties, chemical specifications and application recommendations of "Waukesha Metals."
— The other booklet on WAUKESHA Stainless Steel Castings describing their metallurgical characteristics and application recommendations.
— A postcard or the convenient coupon below will bring either booklet — or both. And, of course, without obligation.

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WAUKESHA FOUNDRY CO., 5304 LINCOLN AVENUE
WAUKESHA, WISCONSIN

☐ Please send me your booklet about "Waukesha Metals" which describes their properties and suggested applications.

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Wheelco Instruments

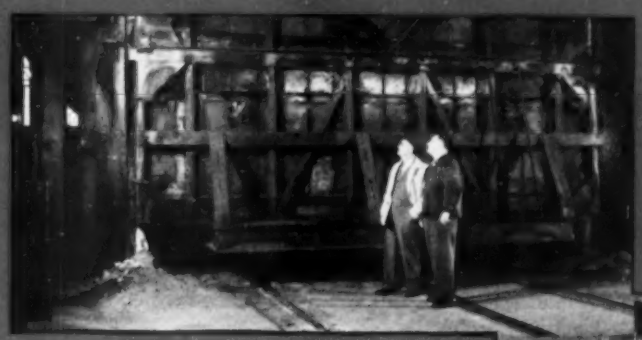
safeguard combustion

of six burners on

giant FALK annealer

Wheelco Multiple Burner Flame-otrols continuously monitor six North American gas-oil burners on this giant car-type annealing furnace at the Falk Corp. In one cabinet, these Multiple Burner Flame-otrols centralize protection for all burners, providing a compact accessible control center. Flame electrodes are mounted at burner ports.

Wheelco Flame-otrols provide for manual or automatic ignition, time delay for purging or a combination of both. For oil or gas, they give you complete flame supervision . . . from safe start to safe shut-off. They're faster, safer . . . because they operate *electronically!*



Giant car-type annealing furnace, converted from oil to natural gas. Wheelco Capacilog Recorders in new control installation measure temperature of two heating zones . . . accurately control heat input at 1650° F. . . . continuously record heating process.

Multiple Burner Flame-otrols cabinet is combined with Recorder panel. Wheelco Capacilog Recorders are flush-mounted at one end of panel.

Operator checks pilot and burner valves. Wheelco flame electrode is mounted at opening in burner port.

Write for bulletin F2—3 . . .

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Gentlemen: I'm interested in learning more about Wheelco Combustion safeguards

☐ Please send free bulletin F2—3 ☐ Have field engineer call

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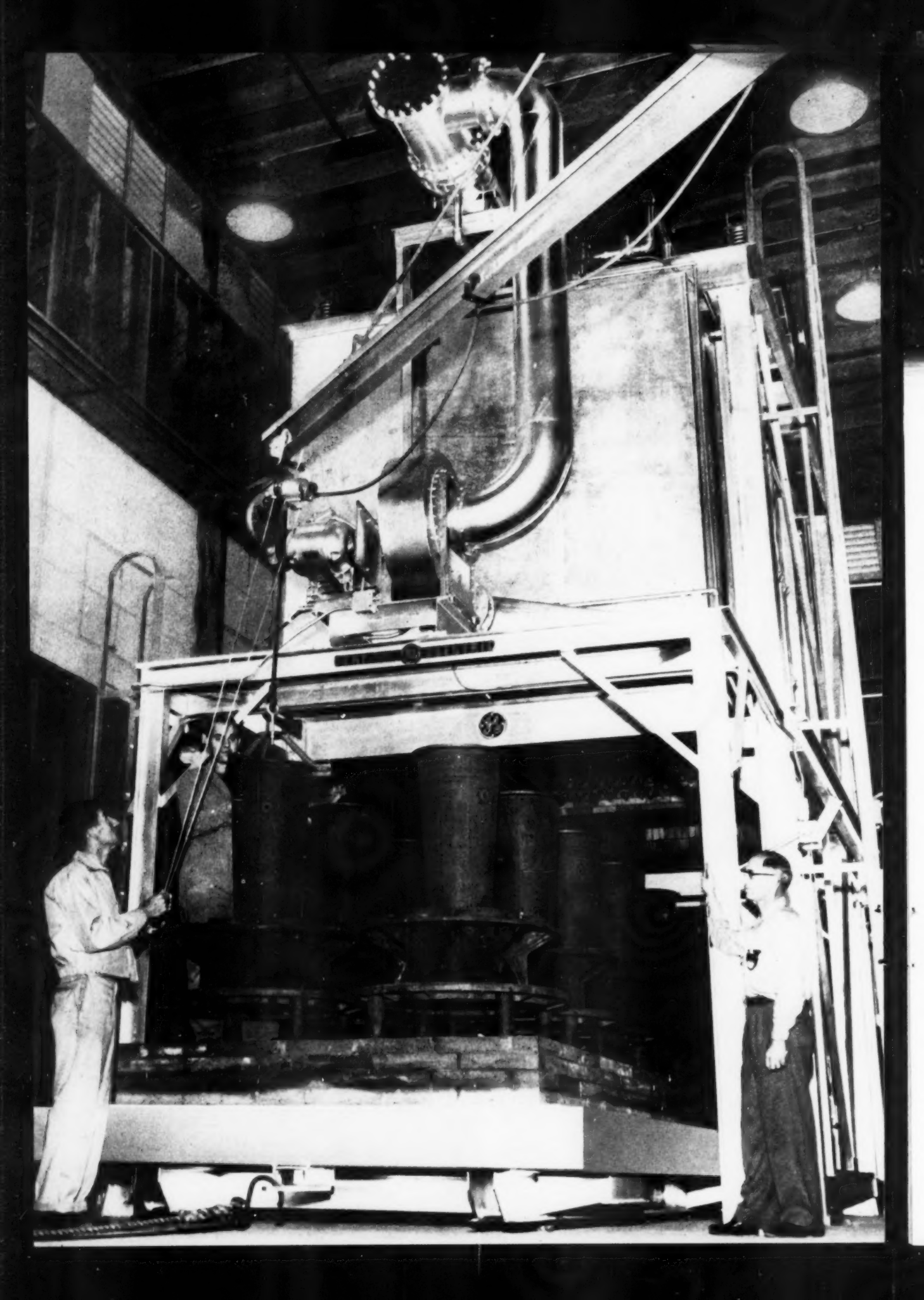
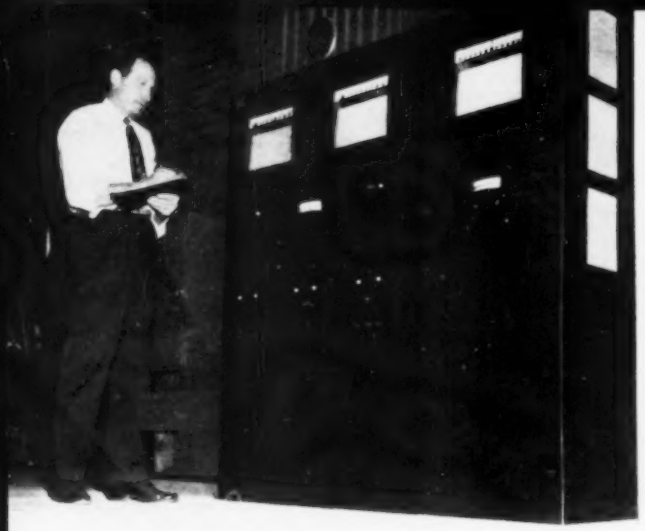
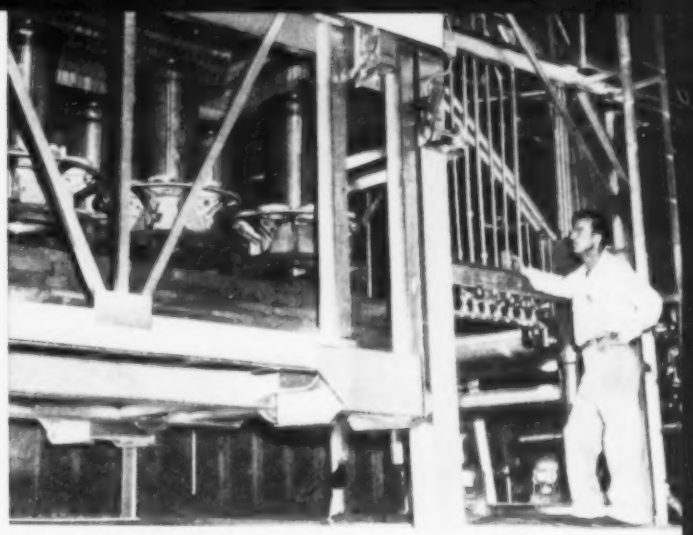




PROPER CONTROL AND TIMING of the complete heating cycle is provided by the G-E heating control unit above. To assure efficient furnace operation and uniform heating of parts, the unit provides automatic programming of heating and cooling cycles.



ONLY ONE OPERATOR is required to supervise temperatures, pressures, cooling phase, and atmospheric conditions. To minimize oxidation of jet parts a G-E gas converter, right, supplies gases of varying analyses as required by the heating cycle.

Solving Ryan's complex heating problem speeds nation's jet engine production

Key to success of America's jet engine program are the subcontractors who back up the large jet engine producers. One of these subcontractors is Ryan Aeronautical Co., San Diego, Cal. In setting up their jet aft frame production, Ryan had the problem of relieving residual stresses without distorting the metal.

After studying the problem with General Electric engineers, Ryan specified a furnace that would provide uniform heating and cooling at 200 F. per hour. Fast production at low cost was also necessary.

Applying years of experience gained in the development of America's first jet engine, G.E. designed and built a special elevator furnace that allows automatic program control of the complete time temperature cycle. This assures uniform heating of each part without weakening the metallurgical structure.

STRESS RELIEVING JET AFT FRAMES in this specially designed elevator furnace is accomplished with minimum distortion of metal. Constructed to assure low cost, high-quality heat treatment the furnace is the result of years of G-E heating research.

Fast cooling is provided by a special blower system that extracts hot air from the furnace, cools it, and then blows it back into the heating chamber. Elimination of costly reducing operations is made possible by using a G-E atmosphere converter to minimize oxidation of the aft frames. As a result Ryan receives consistently high-quality heat treatment.

Heat losses and atmosphere consumption are reduced to a minimum by a specially designed loading car that rolls under the furnace and is hoisted by electric motors to form a completely heat-sealed furnace bottom.

RYAN GETS VALUABLE INSTALLATION SUPERVISION

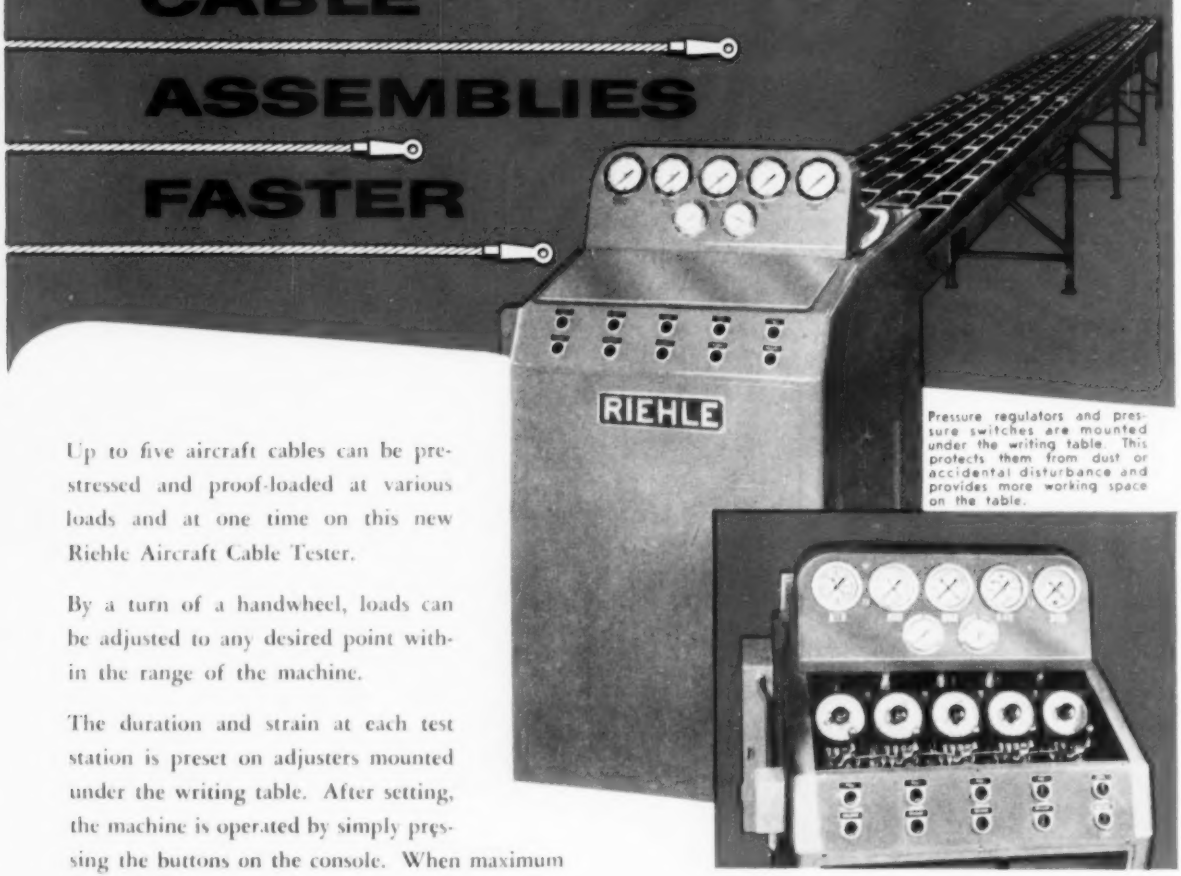
To assure Ryan of proper furnace operation, G-E engineers supervised the complete installation in Ryan's plant. This is standard service from G.E.'s field staff of service engineers – unmatched both in size and experience by any other heating equipment manufacturer.

This example of G.E.'s heating service is a big reason why you should contact your nearest G-E Apparatus Sales Office when selecting your heating equipment. 7B-10

You can put your confidence in—

GENERAL ELECTRIC

TEST AIRCRAFT CABLE ASSEMBLIES FASTER



Pressure regulators and pressure switches are mounted under the writing table. This protects them from dust or accidental disturbance and provides more working space on the table.

Up to five aircraft cables can be prestressed and proof-loaded at various loads and at one time on this new Riehle Aircraft Cable Tester.

By a turn of a handwheel, loads can be adjusted to any desired point within the range of the machine.

The duration and strain at each test station is preset on adjusters mounted under the writing table. After setting, the machine is operated by simply pressing the buttons on the console. When maximum strain has been exerted for the preset time interval, the machine automatically releases the load. After the load is released, the timers automatically reset to zero for the next test. The strain on each cable is recorded on large easy-to-read dials. Each dial has two hands; one records strain at any time and the other records the maximum.

The mooring table accommodates up to 50-foot lengths of cable. Tables for longer cable lengths are available. Safety guards are the open type so that the cable may be conveniently inserted.

The Riehle Aircraft Cable Proof Tester meets all specifications of the Bureau of Naval Aeronautics.

WRITE FOR LITERATURE, SPECIFICATIONS AND PRICES

RIEHLE TESTING MACHINES

Division of American Machine and Metals, Inc.
EAST MOLINE, ILLINOIS

"ONE TEST IS WORTH A THOUSAND EXPERT OPINIONS"

engineering digest OF NEW PRODUCTS

High-Temperature Vacuum Furnace

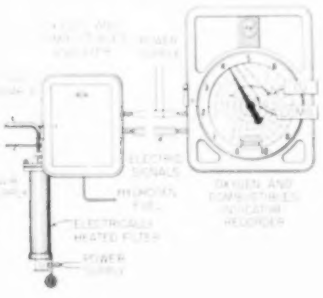
The K. H. Huppert Co. has designed a new type of high-temperature electric vacuum furnace for production and laboratory use where

temperatures up to 2500° F. and vacuums up to 29 in. are required; higher vacuum for special application can be supplied. Furnace and vacuum system can be used independently of each other if desired.

For further information circle No. 633 on literature request card on p. 32-B.

Oxygen and Combustibles Analyzer

A combination Bailey oxygen and combustibles analyzer provides operating information on combustion performance. This gas analyzer can help



save fuel, especially where multi-fuels or fuels of varying composition are fired, and can act as a safety guide to prevent the lighting off of unpurged, gas-fired combustion chambers. Analyses of percentage of oxygen (an index of excess air) and percentage combustibles (an index of fuel-air mixing performance) are offered for the first time in a single, compact unit. The gas analyzer and its recorder indicate or automatically control the necessary adjustments required to maintain maximum combustion efficiency within combustion equipment limitations.

For further information circle No. 634 on literature request card on p. 32-B.

Reversal System for Regenerative Furnaces

A new packaged automatic reversal system for open hearth furnaces and regenerative soaking pits has been introduced by Askania Regulator Co. The system features a compact panel in which the reversal controls are factory-assembled. Reversal can be initiated automatically by elapsed time or checker temperature, or semi-automatically by push-button, as desired. Panel lights indicate firing conditions and reversal sequence. Pistol-grip switch gives operator control.

For further information circle No. 635 on literature request card on p. 32-B.

Salt-Bath Rectification

Graphite rods for low-cost, entirely automatic rectification of electric salt-bath furnaces for high speed steel heat treating have been announced by the Stackpole Carbon Co. Decarburization is avoided, electrode life is prolonged, salt-bath life extended, and better bath circulation speeds heating.

For further information circle No. 636 on literature request card on p. 32-B.

Anode Rod Support

A new type of anode rod support, which provides permanent insulation of anode rods from plating tanks, has been developed by Daniels Plating Barrel & Supply Co. This newly designed support, in addition to the permanent insulating feature, also offers the advantages of simple replacement and greater current carrying capacity.

For further information circle No. 637 on literature request card on p. 32-B.

Flexible Grinding Wheel

A new tool for light grinding and metal finishing is being introduced by Merit Products, Inc. This flexible grinding wheel, which consists of hundreds of individual abrasive cloth

leaves sealed to a hard core, presents a continuous abrasive surface to metal parts. It is designed to smooth surfaces and remove flaws from contours without the danger of digging into the stock.

For further information circle No. 638 on literature request card on p. 32-B.

Cobalt 60 Radiography

Technical Operations, Inc., has announced a portable directional exposure shield for the safe handling of strong sources of cobalt 60 for in-

"16-25-6"*

...used in more jet engine rotor wheels than all other alloys combined!

WAR baby of the Timken Company, "16-25-6" alloy steel helped make jet propulsion practical because it was the *one* steel suitable for commercial production of jet engine rotor wheels. More of it has been used for this purpose than all other alloy steels combined! Reason: it has the *best* combination of the three top requirements for jet engine rotors.

1. GOOD HIGH TEMPERATURE PROPERTIES! Operating in gas temperatures up to 1500° F., "16-25-6" retains high creep and stress rupture strength. And it has excellent resistance to scale and corrosion.

2. LOW IN STRATEGIC ALLOYS! "16-25-6" uses no cobalt or columbium, is relatively low in other strategic alloys.

3. GOOD MACHINABILITY!

The Timken Company will help you adapt "16-25-6" to your purposes—or help you choose other alloy steels suited to today's high temperature, high speed applications. Write The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

* Reg. U. S. Pat. Off.

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

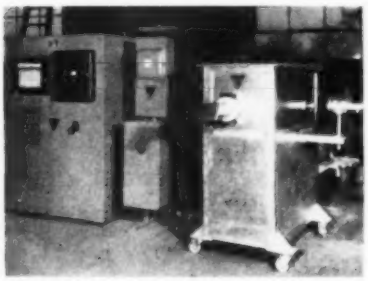
SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS TUBING

dustrial radiography. The shield can be used for thick or thin sections—from 6 in. or more down to only a fraction of an inch of steel, brass or bronze. This equipment functions to shield all radiation from a gamma source except a beam, which may be directed only at the area to be exposed. The source may be raised 56 in. or lowered to 12 in. from the floor. The beam may be varied from straight up to 45° below horizontal.

For further information circle No. 639 on literature request card on p. 32-B.

5000° Tube Furnace

The new Model CT-312 tube furnace for ultra-high temperature work has recently been announced by the Pereny Equipment Co. The equipment is capable of reaching a temperature of 5000° F. in approximately 2 hr. Even-temperature zone of



the furnace is 12 x 3 in. dia., with a full heated length of 26 in. Carbon resistor elements are water cooled and completely protected with fail-safe electrical interlocks. The entire furnace is automatically shut down in the event of water-flow failure to either the transformer or electrodes or both.

For further information circle No. 640 on literature request card on p. 32-B.

Test Chambers

A new line of multi-range, all-purpose test chambers capable of producing low temperatures to

130° F., high temperatures to 200° F. and a standard humidity cycle of 20% to 95% from +35 to +185° F., has recently been introduced by Murphy & Miller, Inc. Made in 5 sizes with test space capacity from 4 to 36 cu.ft., the new units incorporate many features designed to provide faster, easier and more accurate testing. A high-capacity, low-velocity forced air circulation system provided by a fan whose motor is mounted outside the cold test space, reduces temperature variation in all parts of the test space to a minimum.

For further information circle No. 641 on literature request card on p. 32-B.

Strippable Coating

A new fast-drying, strippable coating, by Chemical Development Corp., is a solvent solution applied by dipping, brushing, or spraying for the protection of aluminum and other finished surfaces during drawing and general fabrication, as well as for masking during painting.

For further information circle No. 642 on literature request card on p. 32-B.

Nonmagnetic Test Unit

Bowser Technical Refrigeration has announced a completely nonmagnetic chamber, used in determining effects of temperature on electrical

"TIARCO CORPORATION kromolloy processed" Files

Guaranteed 3 Times Longer Life

ON ALL AMERICAN AND SWISS PATTERN FILES

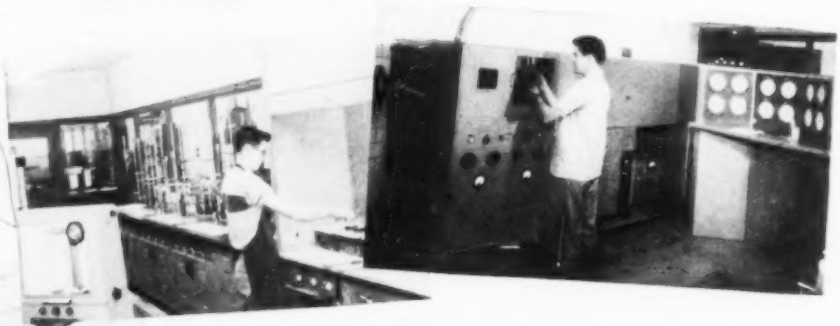
NON CLOGGING • RUST RESISTANT • LONGER LASTING

Tiarco Corporation has appointed LR Heat Treating Sales Co. as distributor of Kromolloy Processed Files. For further information, call or write to:

LR HEAT TREATING SALES CO. 107 VESEY ST. NEWARK 5 N. J. MARKET 2-7795

DISTRIBUTOR OF KROMOLLOY PROCESSED FILES

Final exams for Finkl's Forgings and Die Blocks



From steel formula to finished product, Finkl die blocks and forgings are carefully checked. Analyzed spectroscopically and chemically, tested with Rockwell and Brinnell, and thoroughly inspected by Ultrasonic and Magnaflux methods, Finkl forgings and die blocks are the finest available and at the lowest cost to you.

These tests are run under the keen metallurgical eye of Ted and his crew of technicians, John, Clay, Oscar, and Kenny, assuring you that your forgings and die blocks have passed the most critical modern tests by experts in their field.

Since 1879, "Forgings by Finkl" and die blocks with "Impressions That Last" have been products of the highest quality. When planning your die block or forging requirements, you are invited to call on Finkl's experienced men and modern facilities.

1. Spectroscopic test
2. Chemical test
3. Hardness test
4. Tensile test
5. Ultrasonic test
6. Magnaflux test

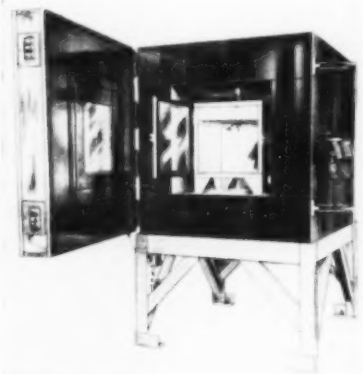
MANUFACTURERS OF THE LARGEST FORGINGS IN THE MIDDLE WEST

A. Finkl & Sons Co.

2011 SOUTHPORT AVENUE • CHICAGO 14

FORGINGS • DIE BLOCKS • ELECTRIC FURNACE STEELS

fields in the development testing of pure metals. Since stray magnetic fields hamper such testing, the new unit is constructed entirely of brass, copper, aluminum, rubber, bakelite, glass, wood and Fiberglass. All motors and electrical components are



located approximately 6 ft. away to eliminate effects of their electrical fields. The unit produces any temperature from −112 to +68° F., with close temperature control. An inner chamber thermally governed by vernier control assures holding of temperatures to ±0.1° F.

For further information circle No. 643 on literature request card on p. 32-B.

Camera Microscope

A new model of the Reichert camera microscope incorporates the following improvements: The transmitted light source is mounted on a rotating carrier permitting more convenient and instantaneous switch from incident to transmitted light and vice versa. The incident light source can be swung to the back enabling the instant employment of an arc lamp. Camera bellows extension is activated by a calibrated drum. Instrument is available from Wm. J. Hacker & Co.

For further information circle No. 644 on literature request card on p. 32-B.

Protective Coating

A newly developed, low-cost protective strippable coating compounded by Ernst Bischoff Co., prevents corrosion or abrasion damage to metal tools and parts during storage, handling or shipment. This transparent ethylcellulose base coating is applied by the hot dip process. It has

AUTHORIZED HONITE DISTRIBUTORS
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These HONITE distributors are experts who have had years of experience in barrel finishing. Your local distributor is equipped to give you complete service on every phase of barrel finishing: equipment, Honite chips and Honite compounds.

He'll show you that HONITE is the longest-lasting, fastest-cutting natural barrel finishing abrasive available today. You'll see that no other barrel finishing abrasive — not even granite — retains its cutting edges as long as HONITE!

He'll show you why low-priced HONITE is not only best, but most economical for fine finishing to close tolerances, and for many other jobs involving a minimum amount of metal removal.

Ask about SUPER-HONITE
World's *Toughest* Abrasive Chip

Only chip engineered for *both* grinding and burnishing. Made of super-hard aluminum oxide mineral grains fused with a ceramic bonding agent. Gives high luster finish in jig time because chips never crumble or pulverize.

Write today for free copy of "3M Barrel Finishing" . . . filled with helpful information on increased efficiency, lower costs.

Address Minnesota Mining & Mfg. Co., Dept. MP-93, St. Paul 6, Minn.

Name . . . . . Title . . . . .

Company . . . . .

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Made in U.S.A. by Minnesota Mining & Mfg. Co., St. Paul 6, Minn. — also makers of "Scotch" Brand Pressure-Sensitive Tapes, "Scotch" Sound Recording Tape, "Underseal" Rubberized Coating, "Scotchlite" Reflective Sheeting, "Safety-Walk" Non-slip Surfacing, "3M" Abrasives, "3M" Adhesives. General Export: 122 E. 42nd St., New York 17, N. Y. In Canada: London, Ont., Can.

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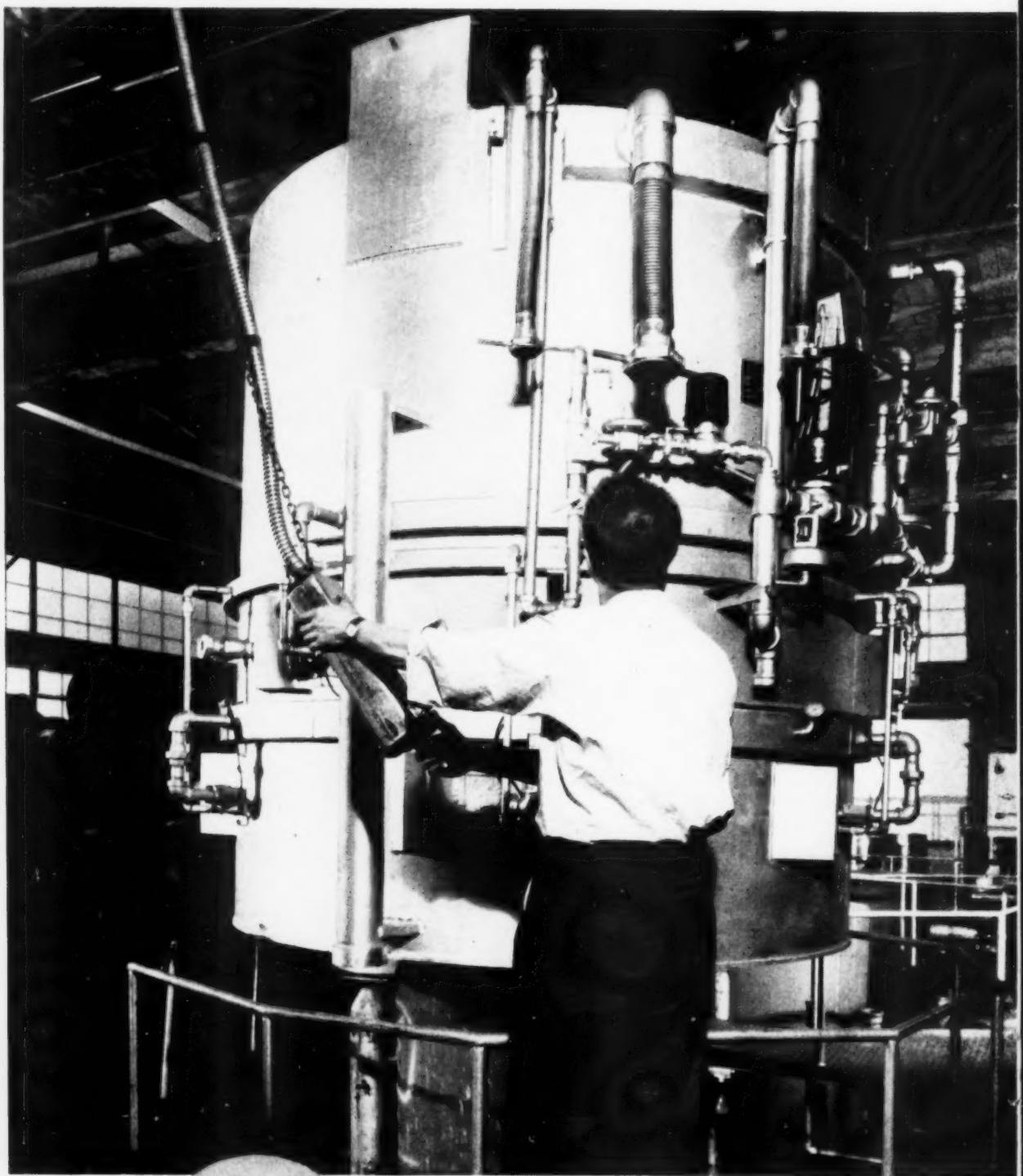


IF YOUR PRODUCT CALLS FOR HEAT-TREATING . . . IT CALLS FOR
A WESTINGHOUSE FURNACE . . . *GAS OR ELECTRIC.*

"Top-quality control with new furnace"

says . . . Rodney Metals, Inc.

"Before acquiring our Westinghouse Bell-Type Furnace we had to depend on outside sources for the bright annealing of our steel stock. This would frequently result in costly delays. Now that we have our own furnace we avoid all breakdowns of production schedules.

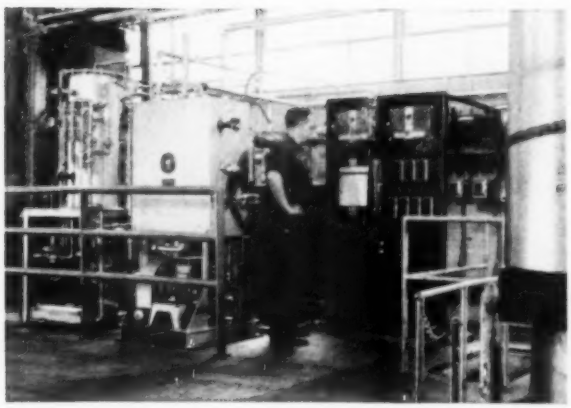
"In a matter of hours, with our Westinghouse integrated operation, our sheet steel warehouse can supply any specific gauge and hardness to the parts manufacturing operation of our affiliated company, Modern Venetian Blinds, Inc. To maintain the high-quality standards of Modern's venetian blind hardware products, it is mandatory that our steel, after annealing, be of uniform hardness and "bright"—free from scale. We have been able to maintain this top-level quality control with our Westinghouse Bell-Type Furnace."

Investigate Westinghouse Heat-Treating Furnaces. Whether it be for your production line, toolroom or laboratory, you'll get the heat-treating flexibility you need and want with Westinghouse Heat-Treating Furnaces . . . GAS or ELECTRIC.

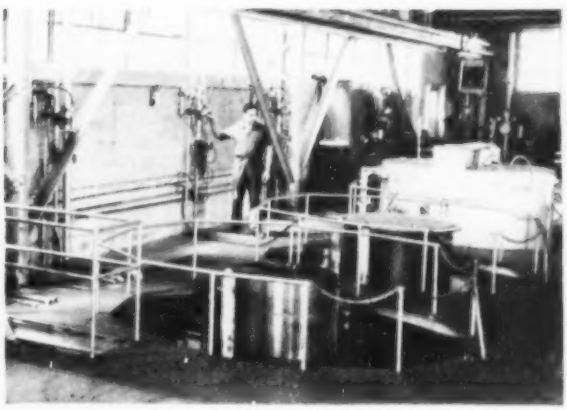
For more information regarding Westinghouse Heat-Treating Furnaces, write today for your copy of the 40-page booklet, *Harnessing Heat* (B-5459) Westinghouse Electric Corporation, Industrial Heating Department, Meadville, Pennsylvania. J-10599

YOU CAN BE **SURE**... IF IT'S

Westinghouse



Exogas® atmosphere generator and control panel used in conjunction with the Westinghouse Bell-Type Furnace. This generator and control panel give constant atmosphere control and absolute temperature reliability.



This is a three-base installation with one Bell, allowing continuous operation. One batch being annealed; one batch cooling under hood; a third batch unloading from base.

been tested for prolonged periods in an atmosphere of 100% humidity at 100° F. without rust or corrosion on steel panels. It can be removed by slitting and peeling, and is re-usable.

For further information circle No. 645 on literature request card on p. 32-B.

Metal Identification

A light-weight, completely assembled metal testing kit by Spot-Testers, Inc., contains all the necessary solutions to identify the following metals and their alloys: Aluminum, copper, tin, nickel manganese, phosphorus, iron, steel, molybdenum, cobalt, lead, antimony, zinc, cadmium, monel, cupro-nickel, nickel-chromium stainless metals, precious and semi-precious metals. Results can be obtained in less than 2 min., and there is enough material for hundreds of tests.

For further information circle No. 646 on literature request card on p. 32-B.

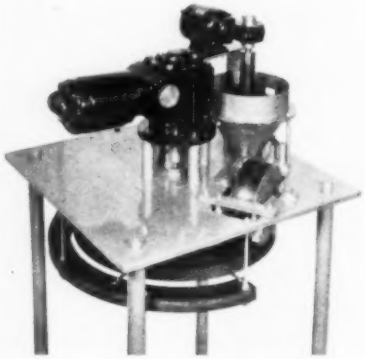
Aluminum Flux

A new type of aluminum welding flux which allows the operator to see exactly what he is doing while welding has been announced by Solar Aircraft Co. The flux becomes liquid when the metal is ready to weld and serves as a temperature indicator, reduces oxides continuously, and is easily removed after welding. The flux eliminates the puddling stick and can be used as a back-up material and with hotter flames.

For further information circle No. 647 on literature request card on p. 32-B.

Moisture Content of Foundry Sand

The Harry W. Dietert Co. has developed an electrical moisture determination machine, the "Waterteller," which takes a continuous flowing sample of core or molding sand from a conveyor or mill. A stream of riddled sand falls on a rubber-faced rotating disk. The sand is struck off

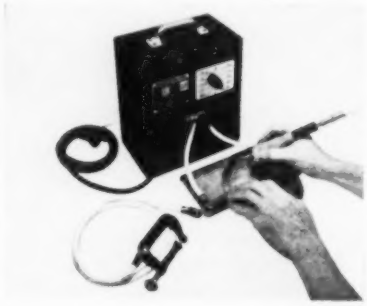


to constant volume and then rammed by a roller to a predetermined hardness. This controlled ribbon of sand is then subjected to a high potential voltage and the current flows through the sand ribbon. The higher the moisture content, the greater the distance the electrical current will flow. The moisture content is thus expressed in distance over a well expanded scale.

For further information circle No. 648 on literature request card on p. 32-B.

Marking Machine

A new portable electric marker for freehand electrical marking on hard or soft steels has been announced by the H. P. Preis Engraving Machine Co. The ten-station rotary switch and regulating knob are important fea-



AMONG A TOOL STEEL SALESMAN'S SOUVENIRS

Here's a punch and a slug — not an unusual punch but one with a history of accomplishment.

A good customer, during the hectic days of World War II, had difficulty getting a 1¾" diameter hole in about 2000 pieces of hot rolled plate 1¼"x 8"x 8" in a hurry. The finished product was a hook-eye to be welded atop buoys, on a Navy job. Burning and drilling were tried but were too slow. With great apprehension a punch and die were made, using Ziv's PLANCHER Tool Steel. The 2000 holes were promptly punched, cold, without a hitch, and both punch and die were good for a good many more.

While you may not be punching 1¼" thick hot rolled plate, you may have other jobs calling for a tough, resilient tool steel, built to be tough, real tough, then it is wise to use Ziv's PLANCHER Silicon Manganese Tool Steel.

Photo Courtesy of Mesker Bros. Iron Co. St. Louis, Mo.

ESTABLISHED 1911

ZIV STEEL & WIRE CO.

ZIVCO TRADE MARK

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New facts for your file on U·S·S CARILLOY STEELS

Every B-36 lands on U·S·S Carilloy steel

● When 179 tons of B-36 thump down on a landing strip, tremendous stresses are built up in the structural parts of the landing gear. Only the highest quality in steel can handle this tough job, which is one of the most exacting in the aircraft industry.

All of the rugged main columns for these landing gears are made from U·S·S CARILLOY electric-furnace aircraft quality ingots. This high quality alloy steel provides the great strength and shock resistance demanded in the performance of the finished part. The main columns for these landing gears are forged. The original ingot, as shipped to the forger, weighs approximately 37,500 lbs. From it are produced two columns, each weighing about 1200 lbs. In other words, approximately 93% of the steel has been removed—with a mere 7% of the original ingot left to do this tremendous job. Obviously, this steel must be of the very best quality.

The same care and skill go into every ton of CARILLOY steel that *you* buy, whether it's a giant alloy ingot or a few tons of special steel. Our experienced metallurgists keep a close check on *every* heat of steel to make sure it has the strength, hardness, toughness and machinability that's needed.

If you have a special steel problem, let us know. We'll be glad to help you with it.

No ordinary steel could withstand the huge shock loads imposed on the main landing gears of Convair's giant Air Force B-36 Bomber. The plane has a maximum gross weight of 358,000 lbs., with still higher landing shock loads. But U·S·S Carilloy steel has more than enough impact strength to hold up under this severe punishment.

U·S·S Carilloy electric-furnace aircraft quality steel meets every requirement for these vital parts. The precision machining and expert heat treatment they get at Cleveland Pneumatic Tool Company complete the job.

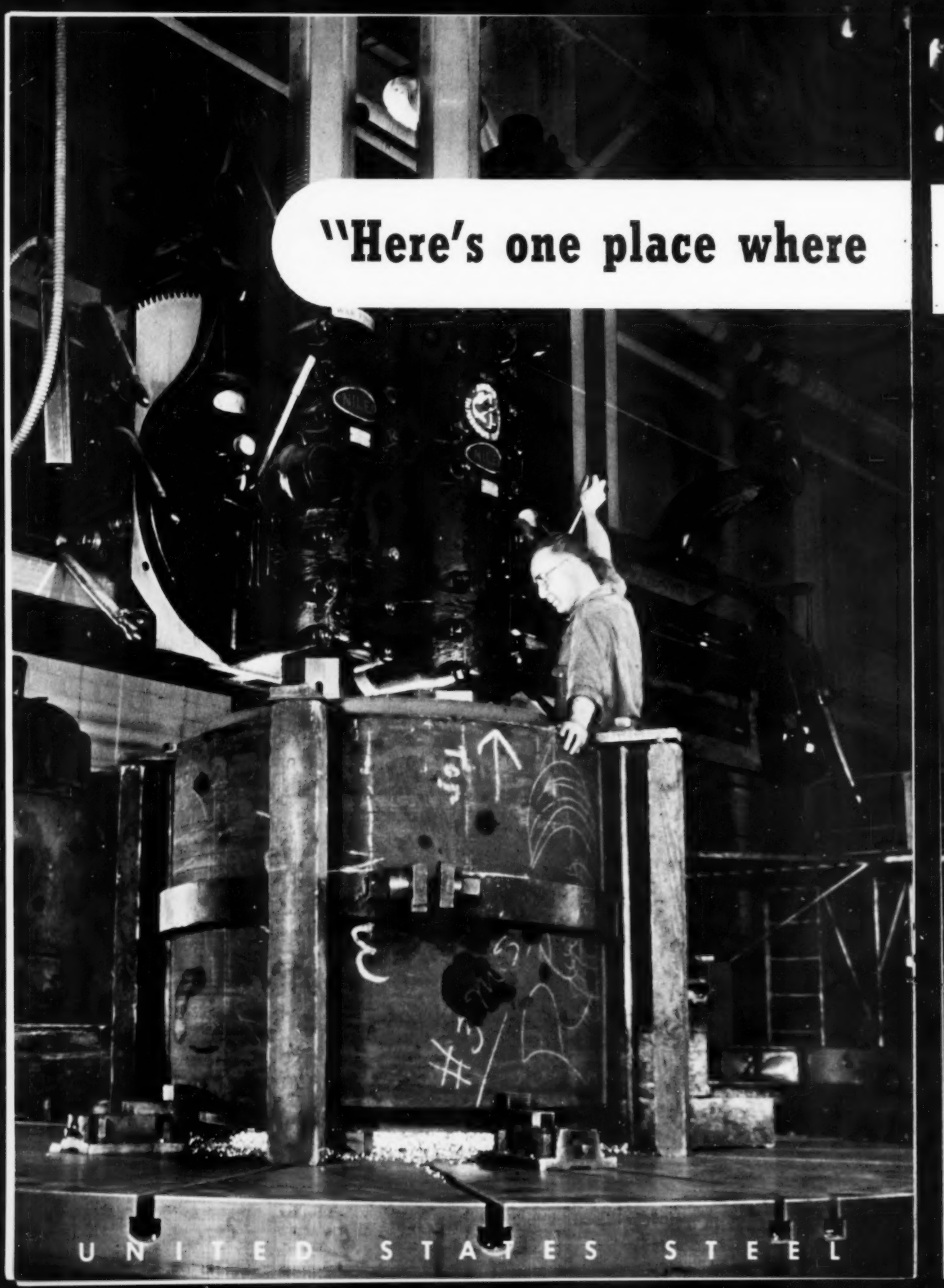
USS

UNITED STATES STEEL CORPORATION, PITTSBURGH · COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO

TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA. · UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS, COAST TO COAST

UNITED STATES STEEL EXPORT COMPANY, NEW YORK

UNITED STATES STEEL


"Here's one place where
UNITED STATES STEEL

everything must be right"

—Says William J. Holohan
U.S. STEEL MACHINIST

HERE in the machine shop of our Homestead Forgings Division the stakes are high. The responsibility is enormous. For here, forgings of all types and sizes—generator shafts, back-up rolls, drop hammer columns, ship shafting, etc.—receive their final "rough" or "finish" machining.

This is the wind-up for all the work that has gone before—the heating, forging, heat treating, the hundreds or thousands of man-hours. The success of the entire job is now in the hands of the machinist. He has to be good.

That's why men like William Holohan are in charge of all machining operations in our Forgings Division.

Holohan has been a U. S. Steel Machinist for 41 years. As an expert on the 12-foot vertical boring mill, he is carrying on a family tradition of fine steel making—following in the footsteps of his father, who retired as a Foreman after half a century of service.

These are the men who make your U·S·S *Quality* Forgings—men, working with the most modern equipment, whose skill and experience are combined to give you always the finest forgings that money can buy.

Send for our free 32-page booklet describing U·S·S Quality Forgings. Write to United States Steel, 525 William Penn Place, Room 2816-I, Pittsburgh 30, Pa.

USS

Quality

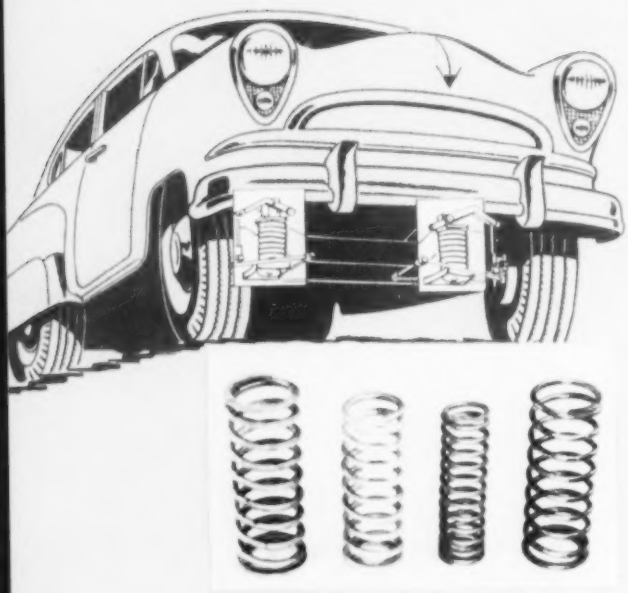
FORGINGS

- heavy machinery parts—carbon, alloy, stainless
- electrical and water wheel shafts
- hammer bases and columns
- marine forgings

New facts for your file on U·S·S CARILLOY STEELS

HALF THE NEW CARS HAVE COIL SPRINGS MADE OF U·S·S CARILLOY PRECISION ROLLED COIL SPRING ROUNDS . . .

- they are twice as accurate as ordinary hot-rolled bars
- require little or no centerless grinding
- *and they cost less to use*



● In the early days of the development of coil springs for front suspensions of automobiles, the only steel that was available was an ordinary hot-rolled bar from which as much as .035" of metal per side had to be removed by grinding to insure freedom from harmful seams, pits, and decarburization. This cost money, was wasteful and time consuming.

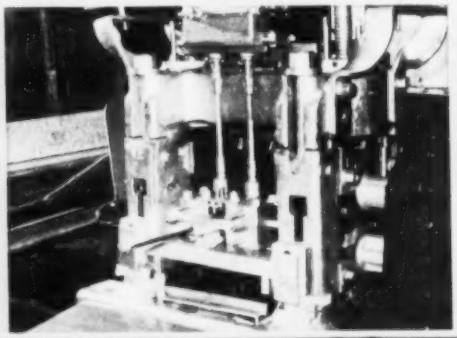
This seemed to be an expensive approach to a simple problem, so United States Steel equipped one of their mills to produce hot-rolled bars to eliminate harmful defects and most of the grinding expense. They devised a method for rolling a bar to half the standard tolerances, with half the amount or less of decarburization, which made it attractive to use the material "as furnished" or with a small amount of centerless grinding. We call this bar a Precision Rolled Coil Spring Round. It has performed excellently when used "as furnished" or with a small amount of grinding.

This exclusive development has paid off in two ways. It paid us because the CARILLOY Precision Rolled Coil Spring Round is now used in over half of the coil springs in new automobiles. But, most of all, it has paid off for the automobile manufacturer in that his costs are reduced with performance of the highest order. Today we are still hard at work developing new and better alloy steels for other new uses in automobiles; for example, in automatic transmissions, power steering units and other new and vital automobile parts.

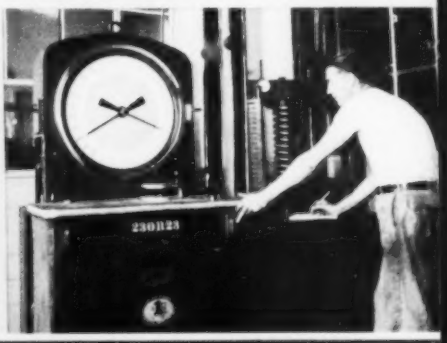
Our experienced engineers and metallurgists will be glad to consult with *you* on any steel or fabrication problem. Just write to United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

Here, at Muehlhausen Spring Division of Standard Steel Spring Co., precision rolled U·S·S CARILLOY Coil Spring Rounds are coiled without centerless grinding. CARILLOY Rounds have a guaranteed minimum decarburization, and they cost less to use.

At the Gary Works of United States Steel, this precision mill rolls CARILLOY Coil Spring Rounds with extreme accuracy. Tolerances are only half of standard; .004" on the diameter, instead of the usual .008", and only .006" out of round, compared to .012" on ordinary rolled bars.



Coil springs made of CARILLOY Precision Spring Rounds have been proved in severe laboratory tests, as well as in actual service on America's best automobiles. They perform so well that half of all automobile coil springs are now made of CARILLOY steel.



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UNITED STATES STEEL EXPORT COMPANY, NEW YORK

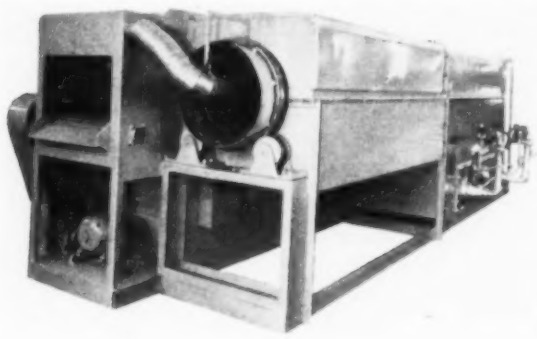
UNITED STATES STEEL

tures of this new marker because they enable the operator to make a light or bold mark at will by simple adjustment of the dial. The marker is suitable for gage blocks, highly finished precision dies and parts that other marking might damage, as well as for routine applications.

For further information circle No. 649

Washing Machine

Metalwash Machinery Corp., announces a new washing machine combining a rotary drum and a flat belt conveyor. It is designed to remove drawing compounds, cutting oils, grease, and shop dirt from metal parts. Small parts that

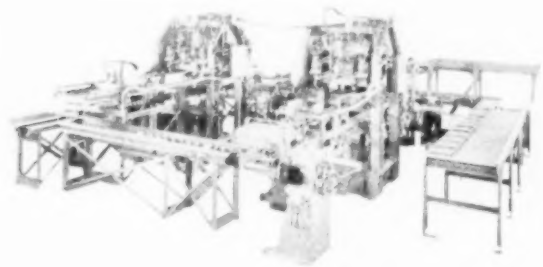


can be tumbled are washed, rinsed and dried in the drum, while the tote boxes and larger parts are processed on the conveyor.

For further information circle No. 650 on p. 32-B.

Automatic Mold Machine for Foundries

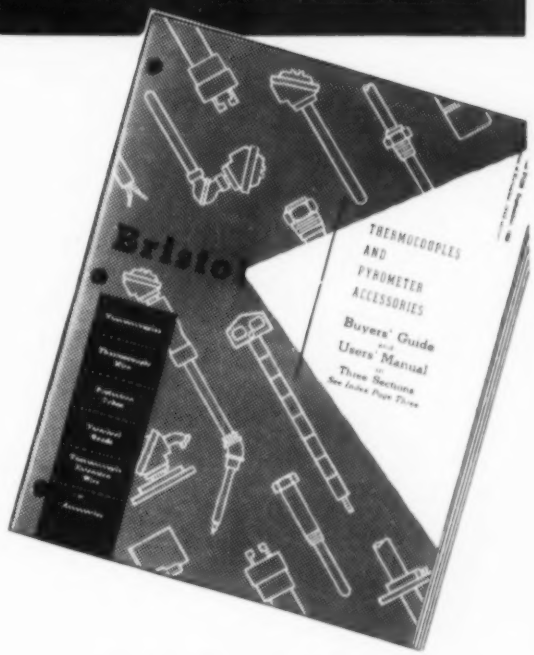
Spo, Inc., has announced a new fully-automatic machine that will produce more than 300 molds per hour. This new Spomatic machine features a straight-through production cycle, accurate control, and consistent production of high quality molds. Designed to operate on



standard 80 psi. line pressure, the unit is controlled by means of solenoid valves. A complete cycle, fully automatic, begins when overhead metering box assembly is filled from machine's hopper and then pulls an empty flask onto strip frame, which is positioned over the pattern. Flask is lowered, positively positioned, and then charged by metering box. Filled flask is given a predetermined jolt.

As metering box assembly returns to refill and pick up another flask, the tandem-mounted squeeze head is positioned over jolted flask, and squeeze operation is accomplished while metering box is being refilled. Stripping operation begins as the squeeze head retracts. Metering box assembly then moves into position with another

If pyrometry plays a part in your business



THIS IS THE MOST HELPFUL BOOK YOU COULD HAVE IN YOUR FILES!

Here, in this well-indexed 56-page booklet is everything you want to know about thermocouples and pyrometers.

- **HELPS YOU SELECT THE RIGHT THERMOCOUPLE**, wire, and protecting tube for every installation. Complete information on all thermocouples and radiation pyrometers, with installation suggestions.
- **HELPS YOU KEEP THERMOCOUPLES ON THE JOB.** Complete, well-tabulated descriptions of replacement parts and accessories, with simple ordering instructions.
- **HELPS YOU GET QUICK, ACCURATE CALIBRATION DATA.** Calibration tables for all commonly used thermocouples, in Centigrade and Fahrenheit scales.

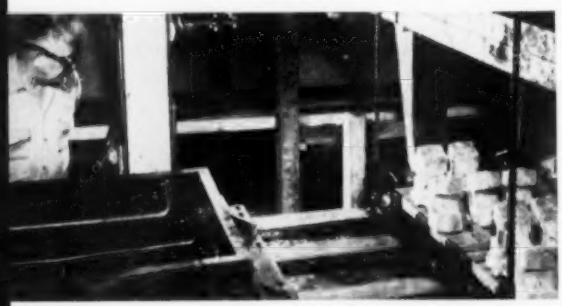
SEND FOR FREE COPY TODAY! Write The Bristol Company, 106 Bristol Road, Waterbury 20, Conn.

BRISTOL *THE DEPENDABLE GUIDEPOST OF INDUSTRY*

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

Picture shows how oil that forms sludge can clog cooler. Sun Quenching Oil's natural detergency helps prevent such sludge formation.

Oil Coolers Don't Clog with

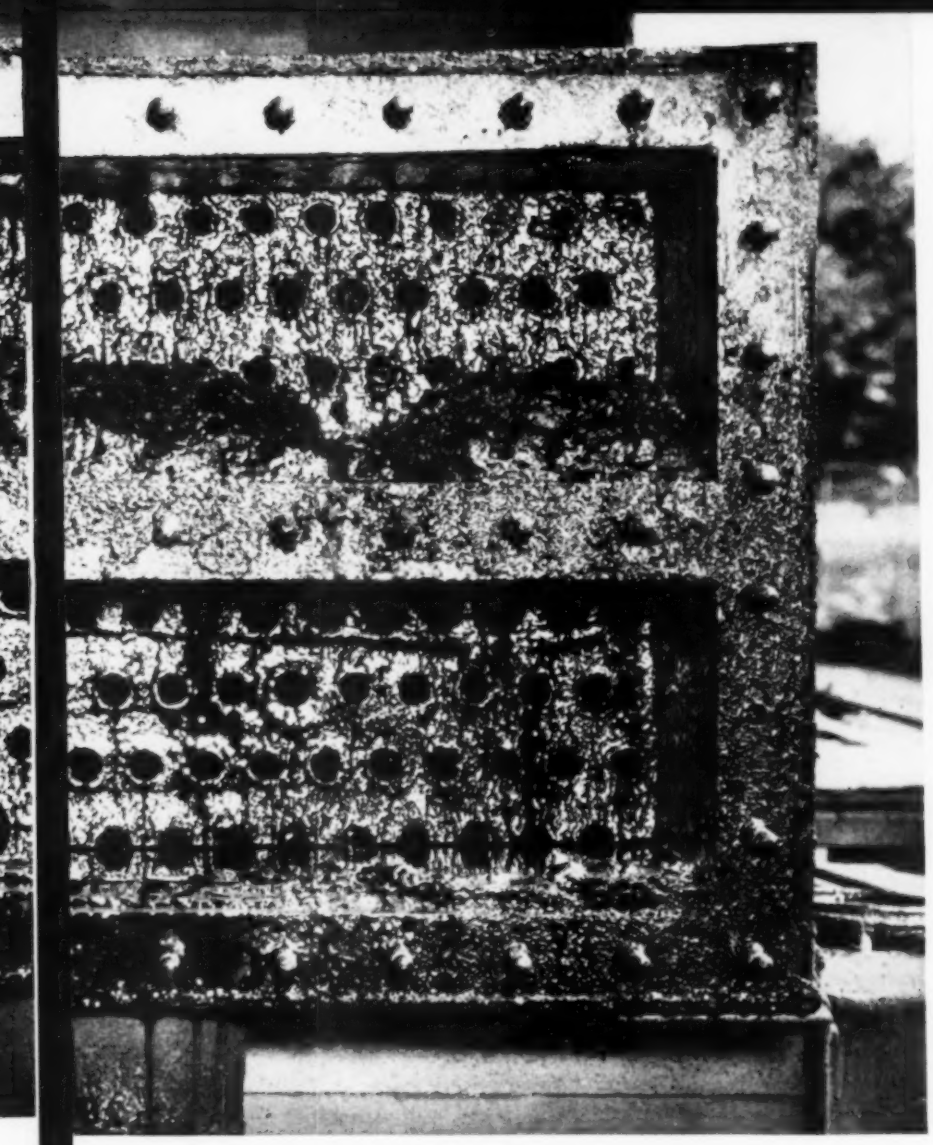


A New England firm uses five 2400-3000 gallon systems to quench all types and sizes of aircraft and automotive forgings. Since Sun oil was adopted 7 years ago, not one system has required cleaning except for normal removal of mill scale.

Sun Quenching Oils keep oil coolers clean. Teardowns are fewer and maintenance costs less. This is because Sun oils have a natural detergent action that prevents the formation of sludge and aids in removing any deposits that exist.

Can Handle 95% of All Quenching Jobs

Tests show that Sun Quenching Oils give better all-around results. For one thing, they assure hardnesses far above the commonly accepted minimum requirements. In any system that provides normal agitation, they can handle 95 per cent of all quenching jobs.



Sun Quenching Oil

Sun Quenching Oils Reduce Operating Costs
Sun oils thin out when heated, drain off parts faster and more completely. Dragout is reduced to a minimum. They do not thicken up, and under normal operating conditions need never be replaced. For more information about Sun Quenching Oils, call your nearest Sun office or write to SUN OIL COMPANY, Philadelphia 3, Pa., Dept. MP-9.

INDUSTRIAL PRODUCTS DEPARTMENT
SUN OIL COMPANY
SUNOCO

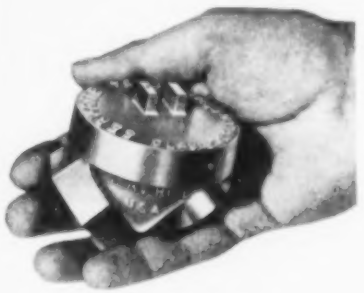
PHILADELPHIA 3, PA. ◆ SUN OIL COMPANY LTD., TORONTO & MONTREAL

flask is being charged and jolted, the first flask is rolled over and carried out of the machine on rollers to a conveyor.

For further information circle No. 651 on literature request card, p. 32-B.

Thermocouple Head

A new thermocouple head has been announced by Claud S. Gordon Co., designed for compactness and elimination of excessive bulk and weight. A friction-lock cap can be tightened



or removed by a quarter turn. An asbestos gasket assures moisture tightness. The connector block is of heat-resistant material specially selected to withstand, without damage, temperatures up to 900° F. in continuous service.

For further information circle No. 652 on literature request card, p. 32-B.

Spring Material

A new copper-base alloy containing about 10% nickel, 1.5% silicon and 4% aluminum has been developed at Battelle Memorial Institute. It was made for electrical contact springs in large accounting and billing machines; other possible uses are seen in the production of aircraft instruments and electrical equipment where high-strength springs are required. Like the copper-beryllium alloys, the new alloy can be made hard and strong, yet be soft enough for forming before hardening. Its electrical conductivity and strength are not quite so high as in the copper-beryllium alloys.

For further information circle No. 653 on literature request card, p. 32-B.

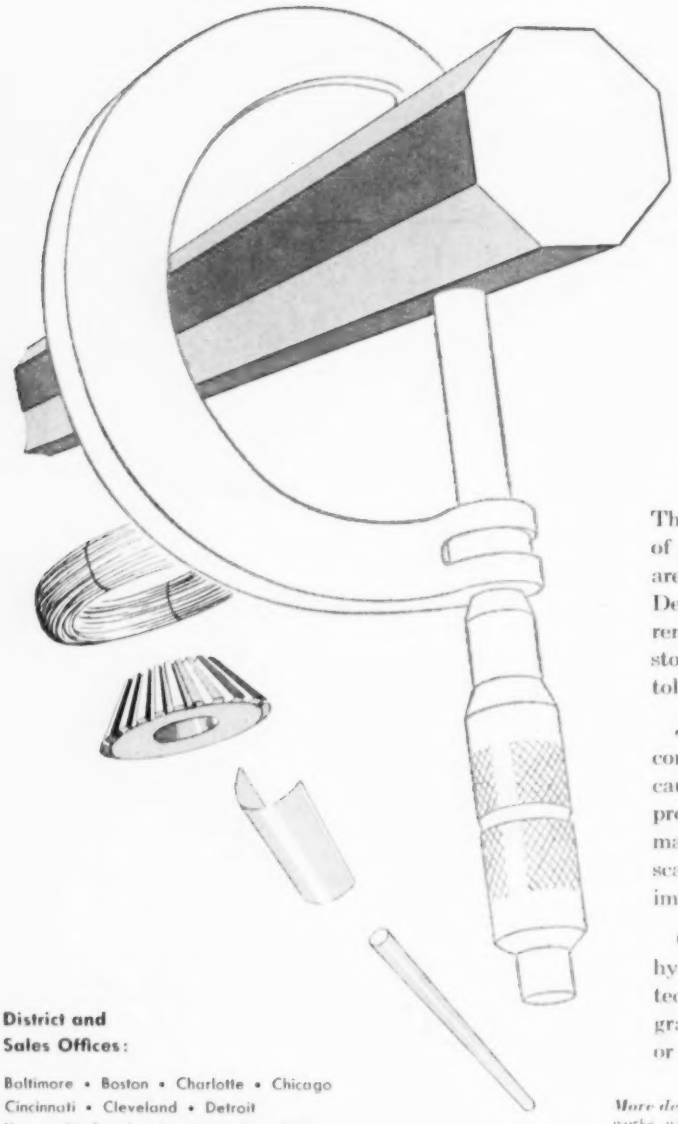
Heat Treating Unit

Ferguson Equipment Corp. announces an automatic production line unit which can be used for the clean heat treatment, carburizing or dry cyaniding of small or large parts which do not have to be handled on trays. The Unitline can be made for individual running of 1 to 4 different

Stop Rejects and Costly Base Metal Losses

use the

DU PONT SODIUM HYDRIDE DESCALING PROCESS



High dimensional accuracy for work of all shapes and sizes!

There is *never* any danger of etching, pitting or loss of gauge when stock in process or finished articles are descaled in a Du Pont Sodium Hydride Bath. Descaling action stops the *instant* scale has been removed. This eliminates base metal losses and stops rejects . . . permits you to work to closer tolerances throughout all manufacturing steps.

Just one fast treatment is all that's needed for complete descaling of all metals not affected by fused caustic at 700°-750°F. This speed makes the Du Pont process ideal for production line set-ups, whether manual, conveyorized or continuous. And since all scale breaking operations are eliminated, you get important savings in time, labor costs and floor space.

Get all the facts from Du Pont—pioneer of sodium hydride descaling. Specialists will be glad to provide technical assistance for your metal cleaning program. Just get in touch with our nearest district office, or send in the coupon below.

More detailed information about the process—how it works, what it can do for you—can be found in our new book. Call our nearest office or use the coupon below for your copy.

E. I. du Pont de Nemours & Co. (Inc.)
Electrochemicals Department MP-9
Wilmington 98, Delaware

Please send me more information about the Du Pont Sodium Hydride Descaling Process: advantages, applications, equipment used. I am interested in descaling _____

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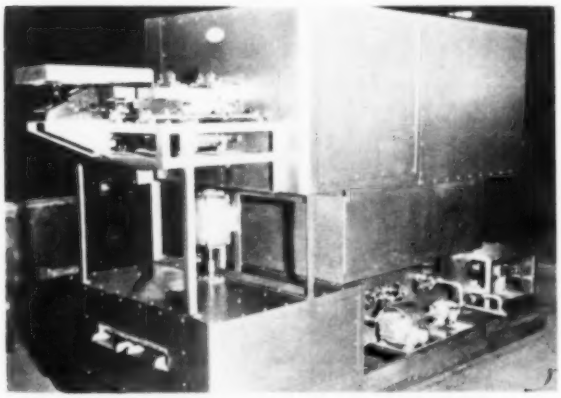
*BARADA & PAGE, INC.

DU PONT
Sodium hydride process for positive descaling

DU PONT

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

parts simultaneously at individual cycles. The unit can be fired with either gas or electricity and the range of temperatures extends to 1750° F. in the hardening furnace

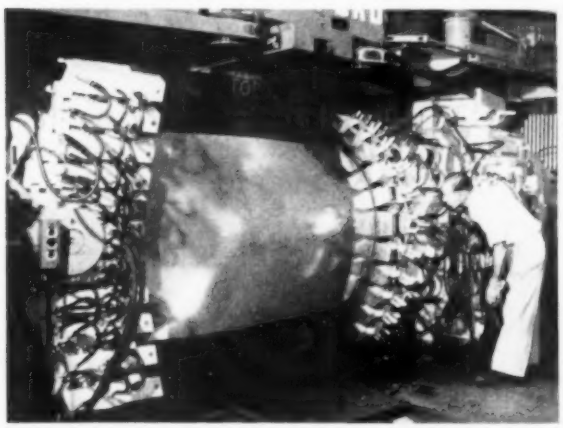


and 1350° F. in the tempering furnace. The production capacity of the units is from 75 to 500 lb. per hour in at least six different sizes.

For further information circle No. 654 on p. 32-B.

Stretch-Forming Operations

A flexible jaw especially designed for use on all types of sheet stretch-forming equipment is made by Hufford Machine Works, Inc. Known as the Hydra-Curve jaw, its function is to grip and curve the sheet to the cross sectional contour of the die. While held in this profile, stretch-forming then completes the longitudinal curves of the part. Use of Hydra-Curve jaws saves as much as 30% of material normally allowed beyond ends of the die for transitional stresses in the sheet. It simplifies formation of all parts with less wrinkling and permits formation of exceedingly deep curves by the stretch-



forming process. Since stresses are considerably lower in the sheet, many aluminum parts can be formed in the ST condition, thus saving furnace hours. Hydra-Curve jaws are composed of numerous segments, each containing a set of hydraulically actuated grippers. The segments are hinged, one to another by pivot pins, thus permitting conformation to a wide variety of die curves —half round, S-shapes, convex or concave forms. Degree of curvature is established by adjustable set-screws, which act as fixed stops in front of and behind each segment.

For further information circle No. 655 on p. 32-B.

Counting Noses

35 Oil-Fired Furnaces

in one non-ferrous metal plant in full production on forging, billet heating, annealing, stress relieving and heating for extrusion are equipped with

HAUCK PROPORTIONING OIL BURNERS . . .

The satisfactory operating results obtained during World War II with these Hauck Burners on a few furnaces have since led to a number of conversions and new furnace installations so that today's total of furnaces equipped with Hauck Proportioning Oil Burners stands at 35.

There must be a reason for such continued satisfactory performance. Catalog 410 tells why. Write for a copy.

HAUCK MANUFACTURING CO.

Combustion Engineers • Manufacturers of Oil and Gas Burners and Equipment

148-158 Tenth Street • Brooklyn 15, N. Y.

NORTH AMERICAN

COMBUSTION EQUIPMENT PUTS HEAT TO WORK IN

The World's Most Modern Foundry

Weld Preheat and Stress Relieve Furnaces
Cleveland Foundry

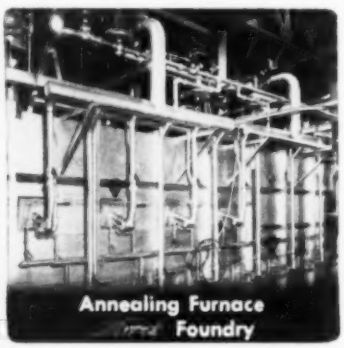
One of 3 identical recirculating furnaces built by R-S Products Corp. Engine blocks and heads are preheated for welding in the 3 zones on the right conveyor and stress relieved in 3 zones on the left. Each zone is heated by a NA* sealed-in tunnel gas burner with a NA* aspirator mixer, atmospheric regulator, and pilot.

Forehearth Preheater
Foundry

One of ten forehearths built by Modern Equipment Co. and preheated with NA* flame retention gas burners. A remote control handle actuates an air control valve and an aspirator mixer and regulator proportion the gas to the air.

Annealing Furnaces
Cleveland Foundry

Four completely conveyorized Hagan direct-fired furnaces for annealing manifolds and small parts. The fuel is natural gas maintained at zero pressure by NA* regulators. Three NA* turboblowers on each furnace supply 1300 cfm of 16 osi air to the 3 heating zones and 3800 cfh of 8 osi air to the air cooling zones.



Annealing Furnace
Foundry

A close-up view of the firing zone of one of the annealing furnaces shown at the left. 26 NA* aspirator burners with NA* pilots are arranged in 3 zones and controlled by NA* air motors and adjustable port valves.

*NORTH AMERICAN – the name that stands for reliable industrial combustion equipment for gas, oil, and dual-fuel. TELL YOUR FURNACE BUILDER that you want North American's experience and scientific know-how built into your next job

The **NORTH AMERICAN**
Manufacturing Company
4455 East 71st St. • Cleveland 5, Ohio

WHAT'S NEW
IN MANUFACTURERS' LITERATURE

673. Abrasion Tester

Bulletins on durable precision instrument for testing resistance of surfaces to abrasion. *Taber Instrument*

674. Abrasive Cutting

20-page booklet 6, "Metallic Cutting Off With Abrasive Wheels." *Abrasives Div., Carborundum Co.*

675. Air-Gas Mixer

Bulletin L-700 gives engineering and application data on air-gas proportional mixer. *Eclipse Fuel Eng'g*

676. Alloy Castings

22-page bulletin 2041 on heat and corrosion resistant castings. *Blaw-Knox*

677. Alloy Steel

Data book on the selection of the proper alloy steel grades for each manufacturer's needs. *Wheelock Lovejoy*

678. Alloy Steel

16-page book on type 9115 low-alloy high-strength steel. Properties, fabrication, welding. *Great Lakes Steel*

679. Alloy Steel

68-page "Aircraft Steels" book includes revised military specifications. Also stock list. *Ryerson*

680. Alloy Steel

32-page book on abrasion resisting steel. Properties, fabricating characteristics, uses. *U. S. Steel*

681. Aluminum Alloys

36-page book on analysis of aluminum, brass, bronze alloy specifications. *Sonken-Galamba Corp.*

682. Aluminum Bronze

Engineering manual on wrought forms of aluminum bronze. *Mueller Brass*

683. Aluminum Extrusions

Data on services in the field of aluminum extrusions. *Himmel Bros. Co.*

684. Aluminum Extrusions

28-page book on extruded aluminum products. Design, tolerances, applications. *Revere*

685. Ammonia Dissociators

Bulletin on dissociating process gives advantages of ammonia as controlled atmosphere. *Sargeant & Wilbur*

686. Arc Furnace Control

8-page bulletin on furnace regulator that automatically balances arc current with arc voltage in metal melting. *Allis-Chalmers*

687. Arc Welding

14-page catalog describes over 20 models of arc-welding machines, with sections on accessories and electrodes. *Air Reduction*

688. Atmosphere Furnace

Bulletin on controlled atmosphere furnace. *Industrial Heating Equipment*

689. Atmosphere Generators

12-page booklet on gas producers describes equipment and gives data on composition and applications of atmospheres. *Bellevue Industrial Furnace*

690. Atmospheres

Bulletin 1-10 supplies technical information on inert gas generators and data on costs. *C. M. Kemp Mfg.*

691. Atmospheres

8-page Bulletin SC-155 discusses following controlled atmospheres: RX, DX, NX, HNX, AX, HX. Compositions, applications, effects on steel, drawings of generators. *Surface Combustion*

692. Atom Models

12-page booklet on construction of scale models of atomic crystal structures. *Fisher Scientific*

693. Automatic Molding

Bulletin MM on fully automatic unit for foundry molding. *Spo, Inc.*

699. Beryllium Copper

Helpful engineering information contained in monthly beryllium copper technical bulletins. *Beryllium Corp.*

700. Blackening Compounds

Bulletin on blackening compounds (for ferrous alloys) to AMS Spec. 2485. *Swift Industrial Chemical*

701. Blackening Copper

Bulletin of operating instructions for blackening and coloring copper and copper alloys. *Enthone*

702. Black Oxide Coatings

Data on black oxide coatings for steel, stainless steel and copper alloys. *Du-Lite*

703. Black Oxide Finish

Four-page article "Low-Cost Black Oxide Finish on Steel by Chemical Dip Method." *Mitchell-Bradford*

704. Brazed Tubing

12-page data book on brazed tubing made from copper-coated steel. *Bundy*

705. Brazing

Bulletin 124—on salt bath brazing process—shows how it is possible to substitute brass for copper and develop joints of adequate strength for most steel assemblies. *Ajax Electric*

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671. Welding Stainless

Here is a 54-page manual on the welding of stainless steel★, suitable for use by anyone having troubles in doing a proper job on stainless. Designers of weldments, as well as production men, will find much important information in this book.

The principal sections will help those who desire to round out their knowledge of processes and the function of flux. Details of welding procedure and hints and pointers for each of the processes are given. Adequate tabulations of recommendations and settings for arc, spot and pulsation welding extend the usefulness of the book. Simple rules of precaution and safety tips are listed.

Soldering and silver brazing are also explained in a sufficiently complete and practical manner to enable the successful use of these methods by the reader.

★Published by Republic Steel Corp. Copies are available at no charge to readers who circle No. 671 on the request card, page 32B.

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694. Automatic Polishing

14-page, illustrated brochure describes automatic equipment for polishing, buffing and grinding. *Murray-Way*

695. Barrel Finishing

16-page manual on "Honite" finishing method for deburring and burnishing small metal parts. *Minn. Mining*

696. Barrel Plating

Folder on barrel plating with unique contact arrangement for maximum current distribution. *Daniels*

697. Bending Aluminum

Bending formulas and radii for 90 and 180° cold bending of various grades and tempers of aluminum. "Technical Advisor No. 18." *Reynolds Metals*

698. Bending and Cutting

Folder describes hand and air-operated bender-cutter and its applications. *J. A. Richards*

706. Brazing and Annealing

Bulletin on high speed heating equipment for brazing, annealing, flame hardening, selective heating, heating for forming. *Gas Appliance Service*

707. Brazing Titanium

Data sheet on use of a new flux for brazing titanium. *Handy & Harman*

708. Bright Annealing

Reprint on bright annealing of copper in atmosphere furnace. *Holcroft*

709. Bright Carburizing

Job data on bright carburizing and hardening gears. *Ipsen*

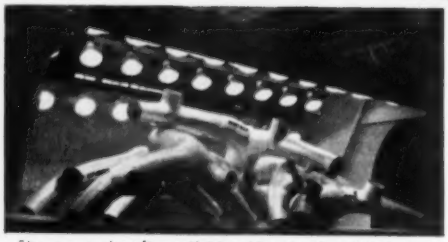
710. Bronze

Folder gives tables of properties, uses, forms and other data on phosphor bronzes. *Chase Brass & Copper Co.*

WHEREVER METAL IS FABRICATED

dy✓chek FINDS THE FLAWS!

Photo courtesy Rohr Aircraft Corporation



Shown are aircraft manifold weldments of stainless steel. Dy-Chek has clearly indicated the presence of dangerous surface flaws in these semi-finished components. *Photo courtesy Rohr Aircraft Corporation, Chula Vista, California.*

Check This Dye-penetrant Method for Positive Flaw Location!

Yes . . . *wherever metal is fabricated* . . . whether the end product be military production or consumer goods . . . progressive manufacturers everywhere are turning to Dy-Chek for positive surface flaw detection. With the Dy-Chek dye-penetrant method, no complicated machinery or involved processes are needed. Yet Dy-Chek quickly and surely locates surface flaws in castings and semi-machined parts of any size, shape or contour. Costly rejects are eliminated at the source and Dy-Chek does it for pennies per day. The biggest names in American industry are using Dy-Chek . . . *endorsing* Dy-Chek. Dy-Chek brings you *better* flaw location . . . *faster* flaw location . . . *cheaper* flaw location . . . *and* Dy-Chek *does it all for less.* We'll welcome an opportunity to demonstrate. Write or wire for complete details today!

FOUR SIMPLE STEPS...

STEP 1: Clean surface

STEP 2: Apply Dy Chek Dye Penetrant

STEP 3: Remove Excess Dye Penetrant with Dy Chek Dye Remover

STEP 4: Apply Dy Chek Developer. Flaws are revealed

For Cleaning or Metal Conditioning Problems...Turn to Turco First!

Hot or Cold Immersion

Spray Washing

Steam Cleaning

Solvent Spray

Phosphate Coating

Paint Removing

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711. Bronze

12-page bulletin on properties and uses of continuous cast bronze rod and tube. *American Smelting & Refining*

712. Burner

Catalog 410 describes proportioning oil burner. *Hauck*

713. Burners

Bulletin on combination gas and oil burner. *Ra-Diant Products*

714. Burners

Bulletin 123 on new series of burners for multi-purpose furnaces. *North American Mfg.*

715. Carbide

Brochure describes sintered chromium carbide for gage blocks. *Firth Sterling*

716. Carbides

64-page catalog 52 gives latest information on carbide tooling. Completely illustrated details on all types of cutting tools. Handy tables for grade selection and cutting speeds. *Kennametal*

717. Carbon Analysis

Folder describes method of rapid carbon determination. *Leitz*

718. Carbon and Graphite

20-page catalog on carbon and graphite applications in metallurgical, electrical, chemical process fields. *National Carbon*

719. Carbon and Sulphur Analysis

Folder on induction furnaces for carbon and sulphur analysis. *Laboratory Equipment*

720. Carbonitriding

Bulletin 241 on gas-fired radiant-tube furnace for carbonitriding and other heat treating. *Lindberg Engineering*

721. Carbon Steel Castings

Data folders on four types of carbon steel castings. Composition, properties, hardenability bands, uses. *Unitcast*

722. Case Hardening

Bulletin 159 describes standard rated batch furnaces for case hardening. *Surface Combustion*

723. Castings, Bronze

16-page booklet on sand and centrifugal castings. *Amer. Non-Grav Bronze*

724. Casting Specifications

Design values for five grades of heat resistant castings. *Ohio Steel Foundry*

725. Cast Iron

"Guide to the Selection of Engineering Cast Irons." *International Nickel*

726. Chromate Coatings

Folder gives characteristics and uses of chromate conversion coatings on nonferrous metals. *Allied Research*

727. Chromium Cast Iron

48-page book on effects of chromium on properties of cast iron. Data on production and uses. *Electro Metallurgical*

728. Chromium Plating

"How to Chromium Plate 20 to 80% Faster" describes self-regulating high-speed bath. *United Chromium*

729. Cleaning

20-page bulletin 214 gives performance on Rotoblast cleaning. *Pangborn*

730. Cleaning Aluminum

Set of seven data sheets on cleaning and finishing of aluminum. *Pennsalt*

731. Cleaning Equipment

Folder on degreaser. Data on different models. *Topper Equipment*

732. Cleaning Stainless

8-page booklet on care and cleaning of stainless steels. *Republic Steel*

733. Coatings, Metal

High-vacuum evaporation of metals set forth in detail in 12-page booklet. *Consolidated Vacuum Corp.*

734. Cold Finished Bars

Engineering bulletin, "New Economies in the Use of Steel Bars." *LaSalle Steel*

735. Compressors

12-page data book 107-C gives engineering information on characteristics of turbo-compressors, 18 types of application described. *Spencer Turbine*

672. Machining Magnesium

64-page book covers turning, boring, shaping, planing, milling, drilling, reaming,

threading, sawing, grinding, polishing and other machining operations commonly used for magnesium alloys. *Dow Chemical*

736. Controlled Atmospheres

Bulletin on Dewpointer for reading of atmosphere in field and laboratory. Readily portable, operating on A.C. or enclosed battery. *Illinois Testing Labs.*

737. Controllers

56-page Catalog 1530 on electric and pneumatic controllers. *Minneapolis-Honeywell*

738. Copper Nickel Alloys

8-page bulletin on composition, properties and applications of series of 12 copper-nickel-base alloys available in cast form. *Waukesha Foundry*

739. Corrosion of Copper

28-page booklet B-36 discusses corrosive attack on copper and copper alloys. Tabulation of their relative corrosion resistance. *American Brass*

740. Corrosion-Proof Cement

12-page bulletin gives corrosion resistance of four types of cement vs. 176 chemical solutions. *Atlas Mineral*

741. Corrosion Protection

Bulletin on Flamespray process for applying protective coatings to exposed metal surfaces. *Bondwel*

742. Corrosion Resistance

20-page bulletin on copper alloys for corrosion resistance. Table gives applicability in 150 media. *Ampco*

743. Cutting Compounds

Data on cutting compounds for stainless and titanium. *Hangsterfer's Labs.*

744. Cutting Fluids

"More Than a Coolant Is Needed" is new booklet describing cutting fluids and lubricants. *D. A. Stuart*

745. Cutting Metals

28-page booklet tells how to cut metals properly with hand and power hack saws and band saws. *Clemson Bros.*

746. Cutting Oil

Facts on more efficient and economical plant operation through use of right lubricants described in "Metal Cutting Fluids" booklet. *Cities Service*

747. Cutting Oil

Folder on sulphurized cutting fluid for a wide range of machining jobs. *Gulf Oil*

748. Cutting Oil Chart

Selection chart for seven classes of metal in nine machining operations. *Aldridge Industrial Oils*

749. Cut-Off Wheels

Folder gives data, operating suggestions and grade recommendations of cut-off wheels. *Manhattan Rubber Div.*

750. Descaling Process

8-page bulletin on sodium hydride descaling process for ferrous and nonferrous metals. *DuPont*

751. Descaling Stainless Steel

Bulletin 25 on descaling stainless steel and other metals in molten salt. *Hooker Electrochemical*

752. Diamond Abrasive

4-page folder on the advantages of diamond abrasives for polishing metallurgical specimens. *Buehler Ltd.*

753. Dilatometer

Bulletin on Chevenard mechanically recording dilatometer suitable for the study of isothermal quenching. *R. Y. Ferner*

754. Ductile Iron Castings

12-page bulletin on pearlitic, ferritic and austenitic grades of ductile iron. 12 typical uses. *American Brake Shoe*

755. Edge Position Control

12-page Bulletin 161 on control system that continuously measures and controls edge position of moving sheet metal. *Askania*

756. Electrical Steel

80-page book of engineering data on silicon steels for the electrical industry. *Republic Steel*

757. Electric Furnaces

Brochure on electric heat treating, melting, metallurgical tube, research and sintering furnaces. *Perény Equipment*

758. Electric Heaters

Bulletin 52 on quartz electric radiant immersion heaters. *Glo-Quartz Electric Heater Co.*

759. Electric Heaters

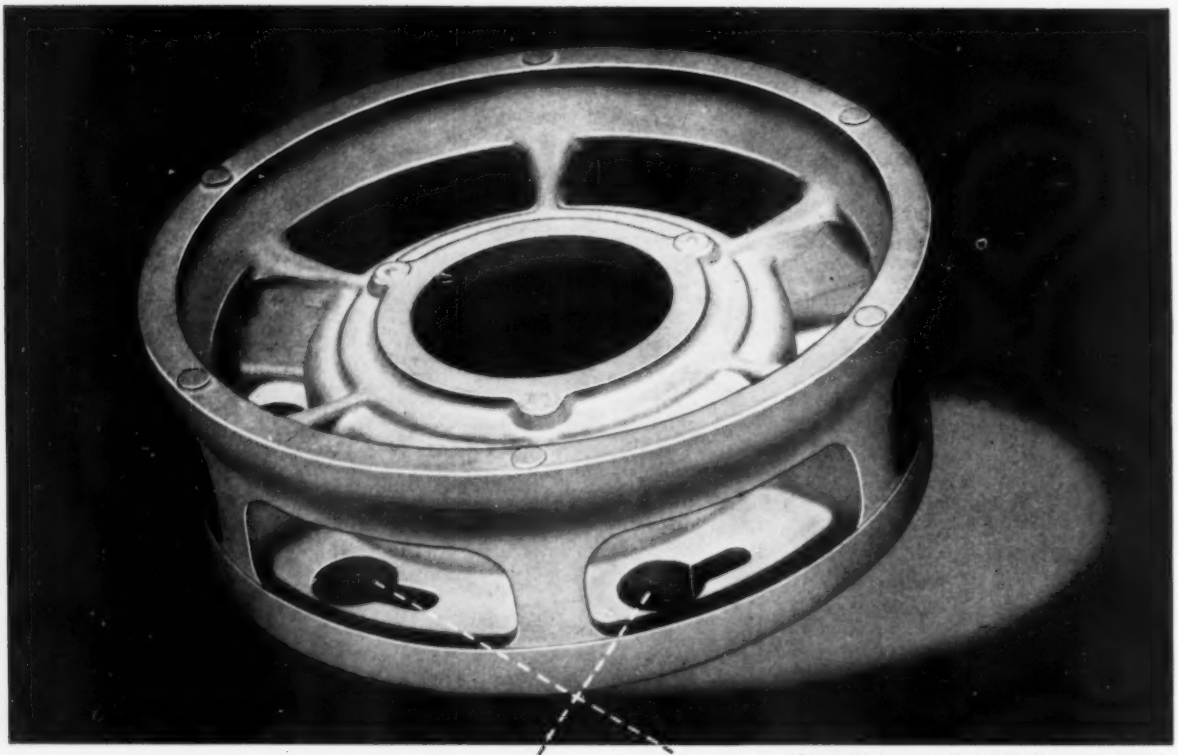
16-page Catalog 53 on various types of electric heating units and controls. *Wunge.*

760. Electric Heaters

64-page Bulletin 1065D on Calrod electric heaters and heating devices. *General Electric*

761. Electron Microscope

New 20-page brochure describes in detail ten case histories in which the electron microscope has been at work solving problems of development and control in industrial laboratories. *RCA*



*FROZEN MERCURY INVESTMENT CASTING

MERCAST* Buttonholes

BUTTON A GENERATOR on or off of an airplane? Westinghouse does! And at a reported time saving of up to 8 man-hours per plane!

The ingenious new Westinghouse generator mounting bracket employs "buttonholes" that permit the assembly to be quickly slipped on or off over headed studs on the airframe. For practical production of this unit, a one-piece precision casting to close dimensional and surface tolerances is the economical answer. This casting, however, is much larger than can be produced by ordinary investment casting processes.

Westinghouse brought the problem to Alloy Precision Castings Company. Engineers and metallurgists at Alloy developed the illustrated 6 lb., 6½ inch diameter mercasting in 410 stainless. Critical tolerances are held to ±.003"/inch. Very little finish machining is required and the "buttonholes" are used as cast. Complete inspection by Alloy assures customers top quality and accuracy.

Mercasting made the Westinghouse generator mount idea a reality. Send details about your "impossible" or "too costly" jobs today! Learn how Alloy Precision can save you time and money with designs for mercasting.

A-6298

ALLOY PRECISION CASTINGS COMPANY, DEPT. C-7
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Please RUSH Bulletin 706 describing the Mercasting Process.

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762. Electropolisher

Bulletin on theory and practice of electrolytic polishing of metallurgical samples. Description of electropolisher. *Buehler, Ltd.*

763. Fatigue of Titanium

5-page article on fatigue characteristics of titanium and three titanium alloys. *Rem-Cru*

764. Finishing

Book, "Abrasive Grain and Powders for Use in Metal Finishing." *Abrasives Div., Carborundum*

765. Finishing

Catalog A-653 gives complete story on planning industrial finishing systems and shows many installations of cleaning and pickling machines. *R. C. Mahon*

766. Finishing

52-page book, "Advanced Barrel Finishing," describes how a single unit may replace from 2 to 12 men. *Almco Div.*

767. Finishing Systems

Bulletin on cleaning and rust-proofing equipment, spray booths and drying ovens. *Peters-Dalton*

768. Flaw Detection

12-page bulletin on location of flaws by two dye-penetrant inspection methods. *Turco Products*

769. Flow Meters

Bulletin 201 on flow meter for gas used in heat treating. *Waukee Eng'g*

770. Flux, Aluminum Melting

Data sheet on four fluxes for degassing and purifying aluminum alloys. *Atlantic Chemicals & Metals*

771. Forgings

Handsome 32-page brochure on large forgings for turbine shafts, rotors, drop hammer anvils, rolls. *U. S. Steel*

772. Forgings

32-page engineering manual of brass and aluminum forgings. *Mueller Brass*

773. Forgings

20-page Catalog 51 on various types of forgings, their strength and related data. Tables, drawings. *Merrill Bros.*

774. Forming

86-page book on equipment and process of cold roll-forming. Wide sheets, narrow trim, tubular shapes, curving, coiling, tooling needed. *Yoder*

775. Forming Dies

Data on roller dies for forming tubes and rolled shapes. *American Roller Die*

776. Foundry Practice

Article on gates and risers with reference to nonferrous practice. *R. Lavin*

777. Foundry Supplies

28-page catalog 1043C on oil and gas-burning equipment for cupola lighting, mold drying, ladle heating, core baking, furnace heating. *Hauck*

778. Foundry Wash

Bulletin on zirconite all-purpose paste wash for foundry applications. *Titanium Alloy Mfg.*

779. Free-Machining Steel

8-page booklet on new free-machining cold finished steel. Eight case histories. *Jones & Laughlin*

780. Furnace Belts

44-page catalog describes metal belts for quenching, tempering, carburizing and other applications. *Ashworth Bros.*

781. Furnace Controls

Bulletin on instruments and controls for heat treating furnaces. *Hays Corp.*

782. Furnace Fixtures

Bulletin 111 on cast Ni-Cr fixtures for gas carburizing. *Fahralloy*

783. Furnace Fixtures

16-page catalog on baskets, trays, fixtures and carburizing boxes for heat treating. 66 designs. *Stanwood Corp.*

784. Furnace Insulation

Bulletin on ceramic fiber that can give impressive savings compared with high-quality insulating brick. *Refractories Div., Carborundum Co.*

785. Furnace Maintenance

16-page "Maintenance Guide for Electric Heat Treating Furnaces" on preventive program. *Hevi-Duty Electric*

786. Furnaces

Bulletin describes 18 electric furnaces for research and small-scale production, with operating temperatures to 3000° F. *Harper Electric Furnace*

787. Furnaces

Bulletin 435 describes new furnaces for tool room, experimental or small batch production. Gas, oil, electric. Muffle or direct heated. *W. S. Rockwell*

788. Furnaces

Folder describes complete set-up for heat treatment of small tools, including draw furnace, quench tank and high temperature furnace. *Waltz Furnace*

789. Furnaces

44-page Catalog 112, well illustrated, features furnaces for hardening, tempering, carbonitriding, forge heating, sintering, annealing and tool heat treating. Also atmosphere generators and ammonia dissociators. *C. I. Hayes*

790. Furnaces

40-page book, describes gas and electric furnaces and applications. Four basic types of atmospheres. Glossary of heat treating terms. *Westinghouse*

791. Furnaces

High temperature furnaces for temperatures up to 2000° F. are described in bulletin. *Carl-Mayer Corp.*

792. Furnaces

12-page Catalog 1-2 on method of atmospheric control for hardening high speed steel. *The Sentry Co.*

793. Furnaces, Heat Treating

12-page bulletin on conveyor furnace, radiant tube gas heated, oil or electrically heated. *Electric Furnace Co.*

794. Furnaces, Heat Treating

32-page catalog on high-speed gas furnaces for heat treating carbon and alloy steels; also pot furnaces for salt and lead hardening. *Charles A. Hones*

795. Furnaces, Heat Treating

Bulletin on fuel and electric furnaces for heat treating. *Dempsey*

796. Furnaces, Heat Treating

Catalog on furnaces for tool room and general-purpose heat treat. *Cooley*

797. Furnaces, Laboratory

26-page "Construction of Laboratory Furnaces" contains many diagrams, charts, tables, and information on how to construct furnaces. *Norton Co.*

HIGH AND LOW TEMPERATURES

NEW BENCH-TYPE TEST UNIT

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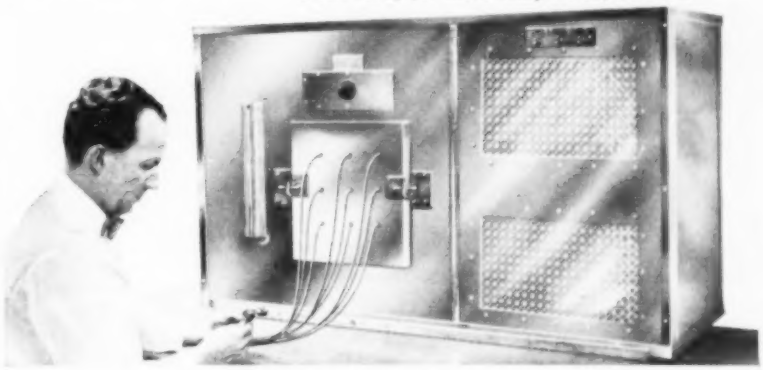

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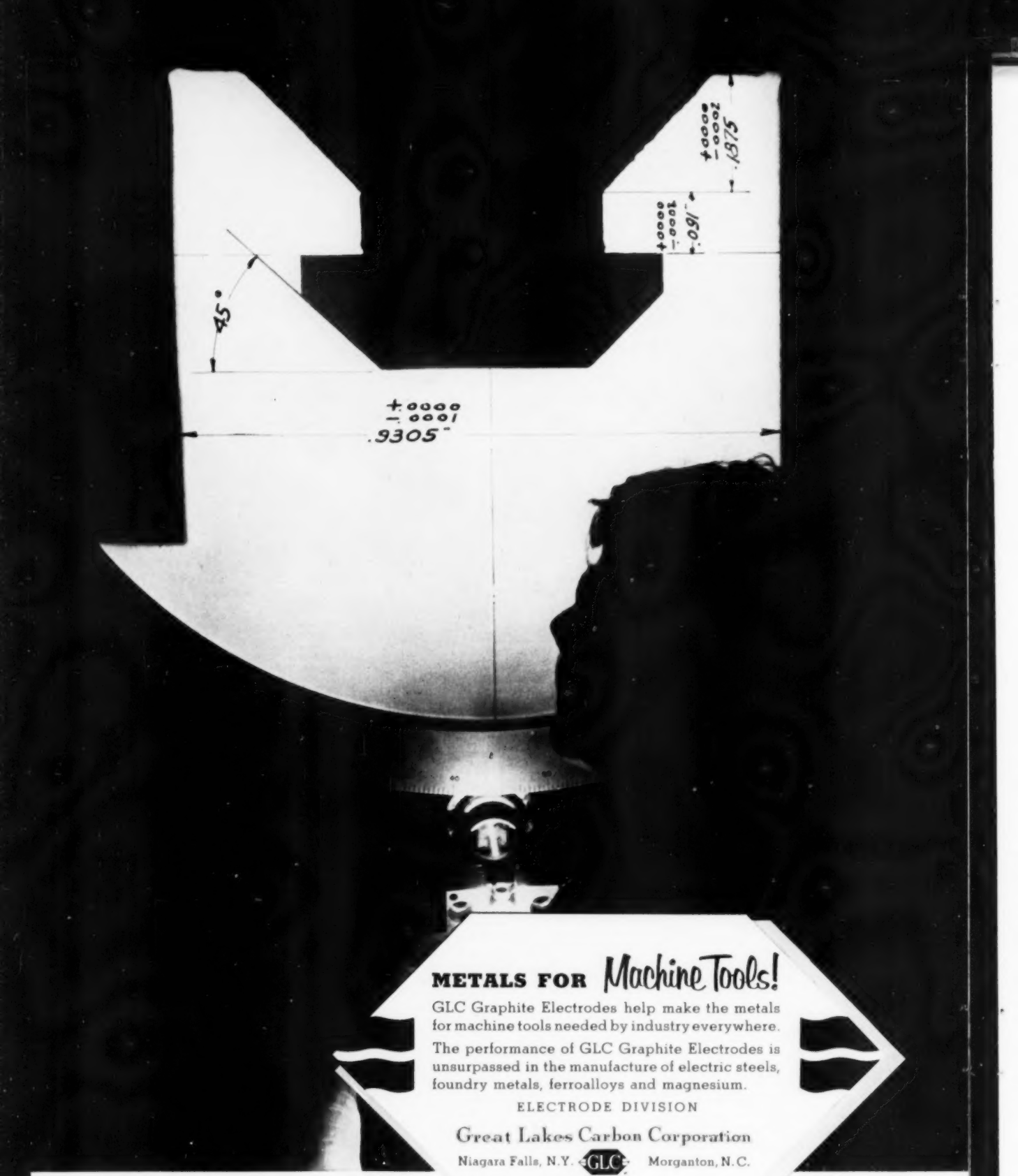

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798. Gas Analysis

Folder on gas analysis equipment for thermal conductivity measurements. *Leeds & Northrup*

799. Gas Analysis

60-page book on theory of gas analysis, procedures, maintenance and operation of equipment. *Fisher Scientific*

800. Gas Carburizing

Bulletin on gas carburizing in rotary furnaces. *American Gas Furnace*

801. Grainal Steel

6-page article on use of grainal as boron-additive alloy and properties of grainal steels. *Vanadium Corp.*

802. Graphite Electrodes

164-page vest-pocket data book on graphite electrodes and electric-arc furnace practice. *International Graphite*

803. Hardening Stainless

24-page "Story of Malcomizing" describes surface hardening of stainless steels. *Lindberg Steel Treating Co.*

804. Hard Facing

12-page bulletin on hard facing electrodes indicates correct type of electrode or rod to use in about 75 common types of hard facing applications. *Alloy Rods*

805. Hardness Conversion

Wallet-size celluloid card gives hardness and tensile conversions. *International Nickel*

806. Hardness Tester

Bulletin ET 439 on new portable hardness tester. *Newage International*

807. Hardness Tester

Circular on portable hardness tester in sizes for work 1 to 6 inches round and flat. *Ames Precision*

808. Hardness Tester

4-page bulletin on Brinell hardness tester weighing 26 lbs. for portable and stationary use. *Andrew King*

809. Hardness Tester

20-page book on hardness testing by Rockwell method. *Clark Instrument*

810. Heat-Resisting Alloy

Pyrasteel bulletin describes chromium-nickel-silicon alloy for service economy in resisting oxidation and corrosion to 2000° F. *Chicago Steel Foundry*

811. Heat Treat Baskets

Bulletin on wire mesh baskets for heat treating and plating. *Wiretex Mfg.*

812. Heat Treating

72-page catalog on carburizing, cyaniding, brazing, austempering and annealing processes. *Ajax Electric*

813. Heat Treating Aluminum

Bulletin on furnaces for aging, annealing, heat treating and forging aluminum. *Morrison Eng'g Corp.*

814. Heat Treating Ammonia

24-page "Guide for Use of Anhydrous Ammonia" describes heat treating and other metallurgical uses. *Nitrogen Div., Allied Chemical & Dye*

815. Heat Treating Fixtures

24-page catalog B-8 on muffles, retorts, baskets, other fixtures for heat treating in gas or salt baths. *Rolock*

816. Heat Treating Fixtures

24-page catalog on heat and corrosion-resistant equipment for heat treating and chemical processing. 30 classifications of equipment. *Pressed Steel*

817. Heat Treating Guide

Chart guide constructed on slide rule principle for simplified hardening and drawing of tool steels. *Carpenter Steel*

818. Heat Treating Pots

Bulletin 110 gives data on sizes and shapes of cast nickel-chromium solution pots. *Fahralloy*

819. High-Temperature Alloy

Property data for 21% Cr, 9% Ni heat-resistant alloy. *Electro-Alloys Div.*

820. High-Temperature Alloys

"Haynes Alloys for High-Temperature Service" summarizes all available data on 10 super-alloys and lists physical and mechanical properties of two newly developed alloys. *Haynes Stellite*

821. High-Temperature Alloys

High temperature work sheet provides valuable suggestions for solving high temperature problems in design and production. *International Nickel*

822. High Temperature Belts

24-page bulletin on metal conveyor belts. *Wickwire Spencer*

823. High-Temperature Steels

87-page book on factors affecting high-temperature properties. 45 pages of data on tensile, creep and rupture properties of 21 high-temperature steels. *U. S. Steel*

824. High-Tensile Steel

Bulletin on nickel-copper steel of low-alloy, high-strength type. *Youngstown Sheet and Tube*

825. High-Vacuum Pumps

36-page Catalog 750 gives formulas, constants, conversions used in vacuum work, pump selection data. *Stokes*

826. Hydrostatic Testing

Bulletin 353 on three machines for hydrostatic testing on a production-line basis. *Steel City Testing Machines*

827. Identifying Stainless

Cardboard chart outlining systematic method for rapid identification of unknown or mixed stocks of stainless steels. *Carpenter Steel*

828. Induction Heating

Book contains selector chart and heating and melting speeds for induction equipment. *Ajax Electrothermic*

829. Induction Heating

Bulletin on new 60-cycle induction furnace for heating aluminum, magnesium, copper and brass for forging, extrusion and rolling. *Loftus Eng'g*

830. Induction Heating

Bulletin on low-frequency (60-cycle) induction heating furnace for nonferrous metals. *Magnethermic*

831. Induction Heating

Data folder on megacycle tube-type machines for soldering, brazing, hardening. *Sherman Industrial Electronics*

832. Induction Heating

"Induction Heating" . . . presents case histories of increased production, reduced space, lower costs. *Westinghouse*

833. Induction Heating

Review of applications of 60-cycle induction heating. *Induction Heating Devices*

834. Induction Heat Control

Data sheet on radiation pyrometer for direct measurement of work being induction heated. *Leeds & Northrup*

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- air
- ammonia
- dissociated ammonia
- butane
- city gas
- endothermic cracked
- exothermic cracked
- hydrogen
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ALOXITE TPT Aluminum Oxide	Tough, sharp. Grits 16 through 100.	Polishing operations involving removal of large amounts of metal (e.g. plowshares).
ALOXITE TPL Aluminum Oxide	Very sharp, friable. Grits 16 through 220. (It fractures during use, thus reduces loading of the wheel surface).	Polishing low tensile strength metals—copper, brass, bronze, aluminum.
ALOXITE TPC Aluminum Oxide	Medium sharp. Grits 16 through 220.	General purpose polishing grain—for removal of small amounts of metal.
ALOXITE TPW Aluminum Oxide	Powder. Grits 240 through 1000.	As the abrasive in paste heading of polishing wheels and belts.
CARBORUNDUM RA Silicon Carbide	Sharp, very friable. Grits 10 through 240.	Polishing cast iron.
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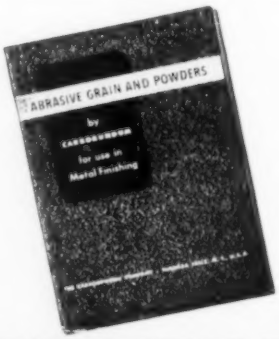

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835. Induction Heat Control

Sheet 83 on miniature radiation-detecting temperature-measuring device for flame hardening and induction heating. *Minneapolis-Honeywell*

836. Induction Melting

8-page article describes use of induction melting in improved technique for rotor-casting. *Ajax Engineering*

837. Inert Gas Welding

Heliwelding, inert-gas-shielded arc-welding process for all-position welding of aluminum, magnesium, stainless steel, brass and copper, in ADC-709, Catalog 9. *Air Reduction*

838. Inspection

Illustrated bulletin on Spotcheck, new dye-penetrant method for locating surface defects. *Magnaflux*

839. Instruments

34-page book describes 37 instruments for electrical, physical, resistance-welding, ultrasonic and other measurements. *Brush Electronics*

840. Iron-Nickel Alloys

32-page bulletin on austenitic iron-nickel alloys having special thermal expansion or thermoelastic characteristics. *International Nickel*

841. Iron 99.84% Pure

Data on composition and price of electrolytic iron melting stock 99.84% pure. *Plastic Metals Div., National Radiator*

842. Laboratory Furnaces

Data sheets on complete line of laboratory furnaces for metallurgical operations. *Boder Scientific*

843. Laboratory Furnaces

Folder describes and illustrates tubular furnace for use in tensile testing, and control panels. *Marshall Products*

844. Leaded Steels

Folder on lead-bearing, cold finished bars which machine about 80% faster than B1113. *LaSalle Steel*

845. Leak Detector

16-page bulletin on leak detector for location and measurement of leaks in evacuated or pressure systems. *Consolidated Vacuum Corp.*

846. Liquid Carburizing

Bulletin gives case depth and hardness vs. time of carburizing; also timing chart for neutral salt baths. *Bellis*

847. Low Temperature Properties

Article on application of extreme low temperatures to metallurgy. Behavior of metals at low temperatures. *Arthur D. Little*

848. Lubricant

8-page folder describes use of molybdenum disulfide lubricant in cold forming, cold heading and other applications. Case histories. *The Alpha Corp.*

849. Lubricant

Uses of colloidal graphite for hot metal-working operations (deep piercing, forging, stretch forming and wire drawing operations). *Acheson Colloids*

850. Machining Alloy Steels

24-page bulletin on economical combination of microstructure, tool form, cutting speed and feed for each machining operation. *International Nickel*

851. Magnesium

42-page booklet on wrought forms of magnesium. Includes 31 tables. *White Metal Rolling & Stamping*

852. Magnesium Extrusions

36-page Bulletin DM134, "Section Properties of Magnesium Extrusions," gives values for moment of inertia, section modulus and radius of gyration of bars, tubing, angles, channels, tees, zees and other sections. *Dow Chemical*

853. Malleable Iron

12-page Bulletin 5797 on electric-furnace annealing of malleable iron. *General Electric*

854. Malleable Iron

Reprint 51-B on metallurgy, treatment, and heat treated properties of malleable iron. *Surface Combustion*

855. Melting Aluminum

Bulletin 310 on furnaces for melting aluminum. *Lindberg Eng'g.*

856. Metal Analysis

Brochure on Quantometer, which furnishes pen-and-ink records of quantitative spectrochemical analyses with extra copies. *Applied Research Labs.*

857. Metal Cutting

64-page catalog No. 29 gives prices and describes complete line of rotary files, burrs, metalworking saws and other products. *Martindale Electric*

858. Metal Hose

18-page Catalog 200 has section on engineering data, including friction losses versus flow rates; also burst pressures and working pressures. *Titeflex*

859. Metallograph

Bulletin on camera microscope and metallograph. *United Scientific*

860. Metallographic Polishing

Booklet describes line of two-speed polishers. *Buehler Ltd.*

861. Micrographic Equipment

6-page bulletin on a universal camera microscope giving plate magnifications from 4 to 3000 ×. Full details on optics and accessories included. *Opplem Co.*

862. Microhardness Tester

Bulletin DH-114 on Tukon hardness testers in research and industrial testing. *Wilson Mechanical Instrument*

863. Microscopes

22-page catalog describes microscopes featuring ball bearings and rollers throughout the focusing system and a low-position fine adjustment, providing comfortable operation. *Bausch & Lomb*

864. Moly-Sulphide Lubricant

10-page booklet on Moly-sulphide lubricant gives case histories for 154 different uses. *Climax Molybdenum*

865. Nitriding Furnace

28-page Bulletin 646 on carburizing and nitriding furnace giving atmosphere circulation to 1850° F. *Hevi Duty*

866. Nondestructive Testing

Series of bulletins gives data on both ultrasonic and magnetic testing instruments. Illustrated. *J. W. Dice Co.*

867. Nonferrous Metals

"Metal of the Month" letters include market trends, statistics, helpful data. *Belmont Smelting & Refining*

868. Nonferrous Tubing

Bulletin on seamless, brazed and lock-seam tubing in brass and copper. *H & H Tube and Mfg.*

869. Nonferrous Wire

Folder gives wire gage and footage chart and data on beryllium copper, phosphor bronze, nickel, silver, brass and aluminum wire. *Little Falls Alloys*

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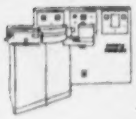

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870. Oil Quenching

Catalog V-1146 on self-contained oil cooling equipment. Selection tables for volume of oil required and oil recirculation rates. *Bell & Gossett*

871. Phosphate Coating

12-page "Phosphate Coating Chemicals and Processes" gives data on paint bonding, rust proofing, protecting friction surfaces, improving drawing and extrusion. *American Chemical Paint*

872. Pickling Baskets

Data on baskets for degreasing, pickling, anodizing and plating. *Jelliff*

873. Pickling Baskets

12-page bulletin on mechanical picklers, crates, baskets, chain and accessories. *Youngstown Welding & Eng'g.*

874. Piercing

Slide calculator for determining the required pressure (in tons) for piercing a given size hole in any thickness and type of metal. *Ward Machinery*

875. Plating

8-page booklet on plating rack designed to make spline section or body of rack a permanent tool. *National Rack*

876. Plating

Bulletin CR-110-5 describes equipment, bath, operating conditions and control of high-speed chromium plating process. *United Chromium*

877. Plating Equipment

16-page bulletin on anodes, anode accessories, plating processes and plating chemicals. *Hanson-Van Winkle-Munning*

878. Plating Generators

Catalog describes motor-generator set for electroplating, anodizing, or electropolishing. *Columbia Electric*

879. Plating Solutions

Bulletin 12 on electric heating of pickling and plating solutions. *Pyrosil*

880. Polishing Machines

6-page bulletin on vertical and horizontal machines for buffing and polishing. *Central Machine Works*

881. Pot Furnaces

Bulletin 330 on furnaces for use with lead, cyanide or other molten bath materials. *Mahr*

882. Pots

Bulletin N-1 on pressed steel pots for lead, salt, oil tempering and metal melting. *Eclipse Fuel Eng'g.*

883. Powder Metallurgy

32-page handbook gives 24 case histories of parts designed or redesigned for powder metal production. Cost comparisons; definitions of terms and list of standards. *New Jersey Zinc*

884. Powder Metallurgy

Information on sponge iron powder. *Ekstrand & Tholand*

885. Precision Casting

44-page Catalog 53 covers every stage of the investment casting process. *Alexander Saunders*

886. Precision Casting

8-page bulletin on investment castings of various ferrous and nonferrous alloys. *Engineered Precision Casting*

887. Precision Metalworking

16-page bulletin on services for melting and casting small ingots, forging and precision rolling, slitting, straightening and heat treating to close tolerances. *Precision Mfg. Services, Hamilton Watch Co.*

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888. Production Heating

Bulletin 511 on gas heating equipment for brazing and annealing. *Gas Appliance Service*

889. Proportioner

Bulletin 630 proportioner, a relay-controlled, air-operated atmospheric regulator to proportion large quantities of low-pressure gas and air for combustion. *North American Mfg.*

890. Punches and Dies

36-page Catalog 152-A on punches, dies and accessories. *Ward Machinery*

891. Pure Metals

Data sheets on vacuum melted cobalt, copper, iron and nickel. *Vacuum Metals*

892. Pyrometer Controllers

8-page Bulletin P1248 on series of electronic pyrometer controllers. *Bristol Co.*

893. Pyrometer Supplies

56-page Users' Manual and Buyers' Guide. Specifications, prices, thermocouple calibration data. *Bristol Co.*

894. Pyrometers

Data sheets on high resistance indicating pyrometers. Also controls and resistance thermometers. *West Instr.*

895. Quenching

Data sheet on mixer for agitation of quenching liquids. *Chemineer*

896. Quenching Oil

8-page booklet on applications and cost reductions in oil-quenching installations. *Sun Oil*

897. Radiation Detector

Folder on radiation detector, full-scale range 250 mr., which operates without batteries. *Consolidated Eng'g.*

898. Radiography

12-page bulletin on X-ray inspection. *Industrial X-Ray, Inc.*

899. Radiography

Bulletin 400-310 on self-contained X-ray unit for mass production inspection of parts. *Westinghouse*

900. Radiography

16-page bulletin on materials and accessories for radiography. Density curves for four types of films. *X-Ray Div., Eastman Kodak*

901. Recirculating Furnaces

16-page Bulletin 81 describes and illustrates heat treating furnaces for ferrous and nonferrous parts and other heat treat equipment. *Despatch Oven*

902. Recorder

Bulletin C2-2 on electronic strip chart recorder for temperature, speed, static strain, voltage, amperage. *Wheelco*

903. Refractories

12-page brochure on products for casting special refractory shapes and for gunning and troweling applications, for services to 3000°F. *Johns-Manville*

904. Refractory Cement

Bulletin discusses refractories and heat-resistant concrete. *Lumnite Div.*

905. Resistance Welding

16-page book on steps in making a resistance weld, metals suitable and controls. *General Electric*

906. Rust Preventives

12-page bulletin on water-soluble rust-preventive. *Production Specialties*

907. Rust-Proofing

Literature on rust-proofing ferrous metal parts. *American Chemical Paint*

908. Safety Valves

Bulletin 400 on safety valves for shutting off fuel in case of power failure to essential unit. *Western Products*

909. Salt Bath Descaling

12-page bulletin B-40 describes continuous and batch descaling lines for removing oxide from steel, bronze, copper, stainless and titanium. *Drever*

910. Salt Bath Furnaces

Data on salt bath furnaces for batch and conveyorized work. *Upton*

911. Salt Baths

32-page bulletin on salts for tempering, annealing, neutral hardening, martempering and carburizing. Heat treating data. *E. F. Houghton*

912. Sand Control

32-page book on defects and troubles in foundry and how to remedy through sand control. *Claud S. Gordon Co.*

913. Selective Carburizer

Bulletin on "No-Carb" for selective carburizing and prevention of decarburizing on high alloy steels during heating for hardening. *Park Chemical*

914. Shearing

16-page catalog on pivoted-blade shears for cutting metal up to 1.25 in. t
Cleveland Crane & Engineering

915. Sheet Metal Testing

8-page folder on equipment for te
the drawing, stamping and folding
ties of sheet and strip. *Deakin*

916. Shell Molding

8-page technical bulletin on shell
ing process for stainless steel. C
Alloy Foundry

917. Shot Peening

Selection and use of shot and gr
peening. *Cleveland Metal Abrasive*

918. Silicone-Base Finish

New brochure on silicone-base
resistant finish. *Midland Ind. Finish*

919. Soldering Aluminum

6-page folder on use of a noncor
flux for soldering aluminum. Data on
strength and ductility. *Insalation
Wires, Inc.*

920. Sonic Thickness Tes

Measurement of wall thickness
one side by sonic method. *Branson*

921. Springs

Data on compression, torsion, fl
tension and special springs. *Evans*

922. Spun-End Tube

32-page brochure on applications o
end tube in copper, brass and alum
19 case studies. *Wolverine Tube*

923. Stainless Castings

8-page bulletin gives recommen
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conditions. *Waukesha Foundry*

924. Stainless Fastenings

20-page catalog of stainless ste
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sheet metal screws, set screws, pipe
and specialties. *Star Stainless Scre*

925. Stainless Steel

Bulletin shows plates, forgings,
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926. Stainless Tubing

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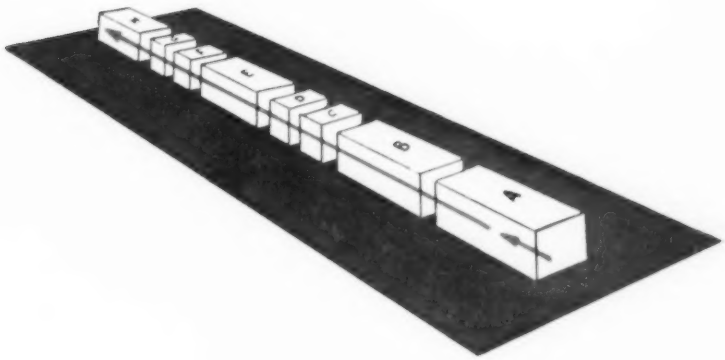

- A Carburizing furnace
- B First hardening furnace
- C Quench tank and elevator
- D Wash and dry
- E Second hardening furnace
- F Quench tank and elevator
- G Wash and dry
- H Draw furnace

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Four furnaces were placed in line. All production was carburized in the first. Part of the work, then, proceeded through the next three furnaces for refining, hardening and drawing. Another portion by-passes the refining operation and is hardened and drawn. The rest of the production is hardened in the second furnace, drawn at high temperatures in the third, and by-passes the fourth.

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J. H. Bradley, A. A. Engelhardt	Wallace F. Schott	R. E. McArdle	Walker Metal Products, Ltd.	S. O. F. I. M.
4209 South Western Blvd.	1900 Euclid Ave.	5724 Navigation Blvd.	Windsor, Ontario	Paris 8, France

FIRST CLASS
PERMIT No. 1595
(Sec. 34.9 P.L. & R.)
Cleveland, Ohio

928. Steel 52100

New stock list on 52100 tubing, bars, and ring forgings. *Peterson Steels*

929. Steel Plate

32-page catalog 1243 on steel plate for carburizing, heat treating and welding. Many uses illustrated. *W. J. Holliday*

930. Steel Tubing

12-page bulletin on electric welded steel tube. *Wolverine Tube*

931. Spring Steels

Spring steel catalog offers 785 sizes of hardened and tempered spring steels, and 133 cold-rolled and bright annealed sizes in stock. *Sandvik Steel*

932. Strain Indicator

Bulletin 4103 on SR-4 Model M portable strain indicator. *Baldwin-Lima-Hamilton*

933. Subzero Freezer

8-page folder on portable freezer, 110-volt a.c., operating to −180°F., for shrink fitting, hardening, stabilizing and testing. *Webber Appliance*

934. Surface Pyrometer

Bulletin 168 on instrument for quick, accurate readings of surface temperatures. *Pyrometer Instrument*

935. Tanks and Linings

16 pages of data on tanks and corrosion-resistant linings for cleaning and plating solutions. *Chemical Corp.*

936. Temperature Control

Catalog of pyrometer supplies gives data on thermocouples, protection tubes, other accessories. *Arklay S. Richards*

937. Test Accessories

22-page Bulletin 46 on instrumentation, tools and accessories for mechanical testing machines. *Tinius Olsen*

938. Testing

Booklet on Reflectoscope tells how ultrasonic vibrations penetrate up to 24 feet to "see" internal defects and fatigue cracks. *Sperry Products*

939. Testing Machines

28-page catalog on screw power universal testing machines and accessories. Construction, specifications. *Riehle*

940. Testing Equipment

New 80-page illustrated catalog lists over 130 testing and measuring equipments for laboratory and production-line use. *General Electric*

941. Testing Machines

Vol. 5, No. 1 shows complete new line of mechanical universal testing machines. *Tinius Olsen*

942. Textured Stainless

Folder on stainless to conserve alloys and reduce weight. *Rigidized Metals*

943. Thermocouples

44-page catalog EN-S2 describes couples and assemblies for general application and for special plant and laboratory uses. Tabular data on accuracy and limits of couples. *Leeds & Northrup*

944. Thermocouples

Catalog 30H on thermocouples, quick-coupling connectors, panels, pyrometers and extension wires. *Thermo Electric*

945. Tin

Monthly newsletter, "Tin News," gives information about prices, supply, demand. *Malayan Tin Bureau*

946. Titanium Fasteners

16-page Bulletin HTA on high-temperature and corrosion resistant fastenings of titanium, Hastelloy, Inconel, Refractaloy, Discalloy and similar alloys. *H. M. Harper Co.*

947. Tool Steel

20-page booklet on selection of proper tool steel support material for use with carbide tools. *Allegheny Ludlum*

948. Tool Steel

Comprehensive data book on drill rod. *Solar Steel*

949. Tool Steel Color Guide

Color guide to estimate temperatures has heat colors on one side and temper colors on the other. *Bethlehem Steel*

950. Tool Steel Selector

Selector is handy chart featuring general and heat treating data on non-deforming, water-hardening, shock-resistant, hot work, high speed tool and hollow die steels. *A. Milne & Co.*

951. Tool Steels

Full information on uses, compositions and heat treatment of carbon and carbon-vanadium tool steels. *Vanadium-Alloys*

952. Treating Torsion Bars

Article describes automatic furnace for heat treating torsion bars. *Sunbeam*

953. Tube Straightening

Catalog describes two-roll rotary straightener for round tubes and bars 1/16 to 3/16 in. O.D. *Medart Co.*

954. Tubing

Bulletin 32 on analyses available, production limits, commercial tolerances, temper designations of seamless and weldrawn tubing. *Superior Tube*

955. Tubing Handbook

Handbook E-4 on resistance welded steel tubing. *Ohio Seamless Tube*

956. Tungsten Alloy

8-page technical information bulletin on tungsten base alloy. Mechanical and corrosion properties; joining, machining, uses. *P. R. Mallory & Co.*

957. Universal Machine

8-page Bulletin 118 on an universal machine tool on which more than 50 different operations can be performed. *Newage International*

958. Vacuum Metallurgy

Bulletin gives résumé of vacuum metallurgical operations and research and development facilities and services available. *National Research Corp.*

959. Welding Equipment

Catalog on Cadweld process and arc-welding accessories. *Erico Products*

960. Welding Pressure Vessels

Reprint describes procedures for welding stainless, stainless-clad and copper alloy pressure vessels and refinery components. *Air Reduction*

961. Weldments

16-page bulletin illustrates a variety of steel weldments. *Struthers Wells Corp.*

962. Weld-Rod Dehydrating

Bulletin on low-hydrogen electrode stabilizer. Specifications of equipment for dehydrating mineral shielding on low-hydrogen electrodes. *Archer*

963. Wire Baskets

84-page book on fabricated baskets for dipping and heat treating. *Cambridge Wire Cloth*

964. X-Ray Inspection

248-page catalog and supplement on materials used in X-ray inspection. *Picker X-Ray*

965. Zinc and Cadmium Plate

Technical data sheets on use of Lusteron salts for zinc and cadmium plating. *Chemical Corp.*

September, 1953

633	658	683	708	733	758	783	808	833	858	883	908	933	958
634	649	684	709	734	759	784	809	834	859	884	909	934	959
635	660	685	710	735	760	785	810	835	860	885	910	935	960
636	661	686	711	736	761	786	811	836	861	886	911	936	961
637	662	687	712	737	762	787	812	837	862	887	912	937	962
638	663	688	713	738	763	788	813	838	863	888	913	938	963
639	664	689	714	739	764	789	814	839	864	889	914	939	964
640	665	690	715	740	765	790	815	840	865	890	915	940	965
641	666	691	716	741	766	791	816	841	866	891	916	941	
642	667	692	717	742	767	792	817	842	867	892	917	942	
643	668	693	718	743	768	793	818	843	868	893	918	943	
644	669	694	719	744	769	794	819	844	869	894	919	944	
645	670	695	720	745	770	795	820	845	870	895	920	945	
646	671	696	721	746	771	796	821	846	871	896	921	946	
647	672	697	722	747	772	797	822	847	872	897	922	947	
648	673	698	723	748	773	798	823	848	873	898	923	948	
649	674	699	724	749	774	799	824	849	874	899	924	949	
650	675	700	725	750	775	800	825	850	875	900	925	950	
651	676	701	726	751	776	801	826	851	876	901	926	951	
652	677	702	727	752	777	802	827	852	877	902	927	952	
653	678	703	728	753	778	803	828	853	878	903	928	953	
654	679	704	728	754	779	804	829	854	879	904	929	954	
655	680	705	730	755	780	805	830	855	880	905	930	955	
656	681	706	731	756	781	806	831	856	881	906	931	956	
657	682	707	732	757	782	807	832	857	882	907	932	957	

METAL PROGRESS,

7301 Euclid Avenue, Cleveland 3, Ohio

Please have literature circled at the left sent to me.

Name _____

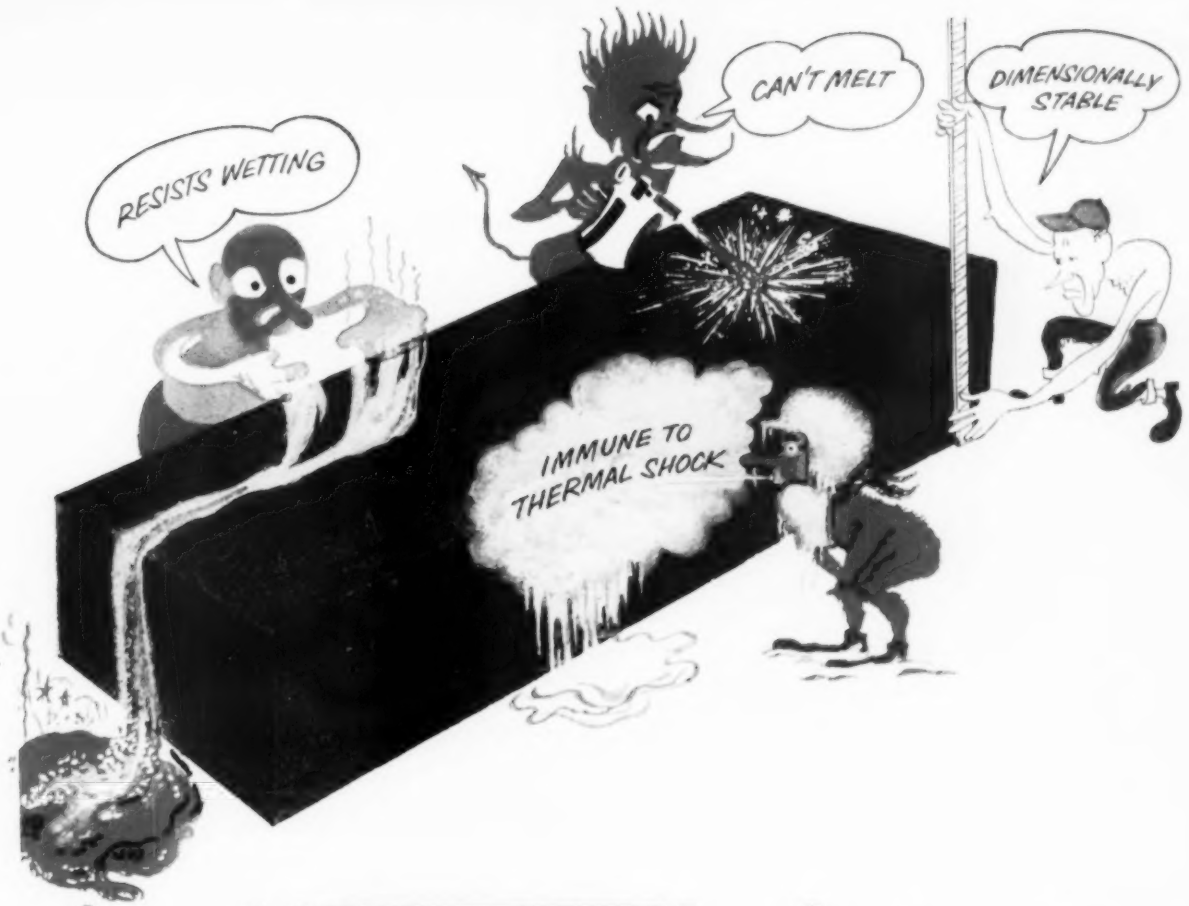
Title _____

Company _____

Address _____

City and State _____

Postcard must be mailed prior to Dec. 1, 1953—
Students should write direct to manufacturers.



Keep NATIONAL Carbon Brick on hand for MAINTENANCE

TRADE-MARK

KEEP THESE STANDARD SIZES ON HAND FOR EMERGENCY!

13½" x 6" x 3" series
9" x 6" x 3" series
2" x 4½" x 2½" series

☆

Write for Catalog Section S-6210

If you think of carbon only in terms of complete furnace linings, check these other important locations in and around the furnace where "National" carbon brick and shapes will also save time and money as a maintenance refractory:

- ✓ ***RUNOUT TROUGHS***
- ✓ ***CINDER NOTCH LINERS***
- ✓ ***CINDER NOTCH PLUGS***
- ✓ ***SPLASH PLATES***
- ✓ ***SKIMMER PLATES***

. . . and Many More!

The term "National" is a registered trade-mark of Union Carbide and Carbon Corporation

NATIONAL CARBON COMPANY

A Division of Union Carbide and Carbon Corporation, *30 East 42nd Street, New York 17, N. Y.*

District Sales Offices: Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco

In Canada: National Carbon Limited, Montreal, Toronto, Winnipeg

Here's a CVC team that meets every *high vacuum* leak detection requirement

Consolidated Engineering Leak Detector, Model 24-101A *(above) is a simplified mass spectrometer sensitive to minute traces of helium. It can be used with either the probe or envelope method. The self-contained unit includes mechanical and diffusion pump; and all necessary controls and instruments.*

CVC Leak Detector, Model LD-01 *(above right) uses a sensitive element containing a heated platinum anode and cold cathode with relatively low voltage between them. The circuit uses standard radio tubes, operates on 115-volt ac current.*

For routine maintenance of your high vacuum system—*CVC's* Model LD-01 Leak Detector is a compact, easily portable unit. It's simple to operate. You just connect the sensitive element to your vacuum system and pump a moderate vacuum. Then, direct a small jet of harmless Freon Gas at suspected spots and watch the meter. You get a direct indication of leak rate.

For production work—the Consolidated Engineering Leak Detector (Model 24-101A) will solve your problems. Whether it's a *large vacuum metallizer, vacuum furnace, refrigerator compressor drying system* or *TV-tube pumping system*, this versatile and extra sensitive unit will tell you when it's absolutely leak tight. Most specifications for hermetically sealed relays now require a leak tolerance detectable *only* with this type of unit.

Operation is simple—just play helium on the suspected area. An audio system tells the size of the leak by a low or high-pitched sound, or you can watch for it on a meter.

Either or both of these instruments will save you many hours of wearisome searching for vacuum leaks. For information on this or any other equipment, for the creation, measurement or use of *high vacuum*, write to ***Consolidated Vacuum Corporation, Rochester 3, New York*** (A subsidiary of Consolidated Engineering Corporation, Pasadena, Calif.) Sales offices: Menlo Park, Calif. • Chicago, Ill. Camden, N. J. • New York, N. Y.

formerly DPi Vacuum Equipment Dept.

CVC

Consolidated Vacuum Corporation

Rochester 3, N. Y.

high vacuum research and engineering

SYLVANIA

Lighting, Electronics, Radio, Television.
Sylvania Electric Products Inc.

How Sylvania Electric cut cleaning costs 52.8% with Pennsalt Cleaners

A striking, although not unusual, example of the value of Pennsalt Cleaners comes from the Radio and Television Division of Sylvania Electric Products Inc.

In its Buffalo plant, this Division stamps out thousands of steel radio and TV chassis and other miscellaneous parts every day which are then zinc plated. After a survey of the plant, the local Pennsalt representative suggested that two Pennsalt Cleaners could definitely reduce cleaning costs in the plating operation.

After a test, the Pennsalt cleaners were adopted, and these were the results of the change:

1. Total consumption of cleaners was reduced in each four-week period from 2700 lbs. to 2140 lbs. including make-up schedules.

2. Previous cleaners cost $432.00 a month. The Pennsalt products run $204.78 a month—*a 52.8% saving.*

3. The Pennsalt Cleaners removed stamping oils and shop grime with equal or greater effectiveness than the previous cleaners and were in every other way completely satisfactory.

Here is a brief introduction to the two products that performed this notable cost-cutting feat: the first Pennsalt Cleaner is a concentrated, extra-heavy duty soak or immersion tank alkaline cleaner with exceptional emulsifying powers. The second Pennsalt Cleaner is an alkaline electrolytic cleaner specially compounded for removal of heavy smut deposits when used in reverse cleaning cycle.

The extensive Pennsalt Cleaner line includes products for virtually every type cleaning operation, and Pennsalt specialists have vast experience in properly applying them.

No matter how effective or economical you believe *your* present cleaners to be, there is a very good chance that a saving similar to Sylvania's can be made in your plant with Pennsalt Cleaners! Contact your Pennsalt representative today or write:

PENNSYLVANIA SALT MANUFACTURING COMPANY
Metal Processing Department
395 Widener Bldg., Philadelphia 7, Pa.

Pennsalt Chemicals

Chance Vought F7U Cutlass

Here's a simple equation:

NO HIGH ALLOY STEEL = NO PLANE

Without stainless steel, super-high-temperature steels and special electrical alloys, it just wouldn't be possible to build, power and control a plane in the over-600-miles-per-hour class. That is our job: to develop and produce such metals . . . and if you have any problems that involve resisting corrosion, heat, wear and great stress, or require special magnetic properties, we're the people to see. *Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.*

PIONEERING on the Horizons of Steel

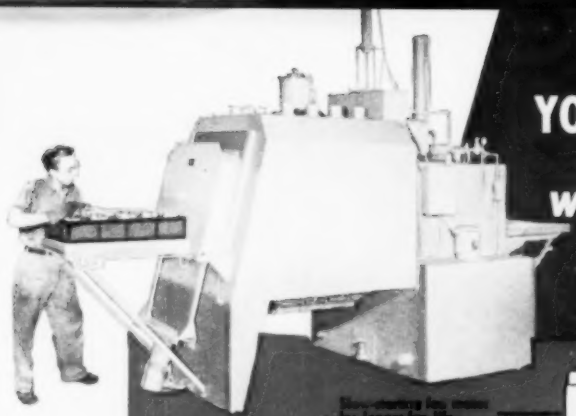
Allegheny Ludlum

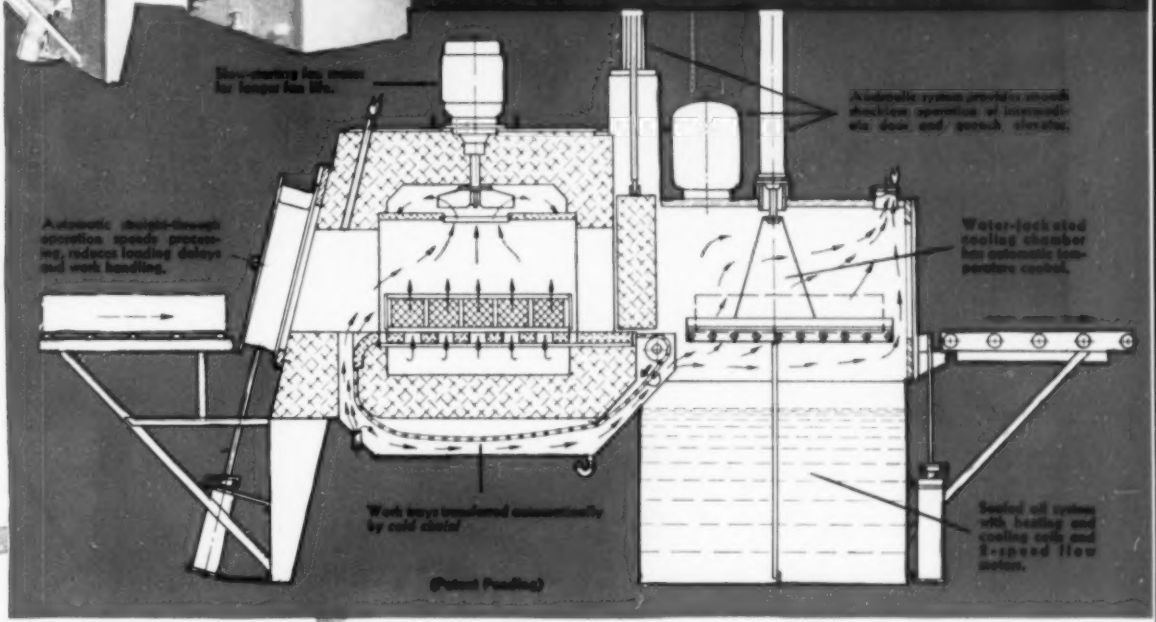
Warehouse stocks of A-L Stainless carried by all Ryerson plants

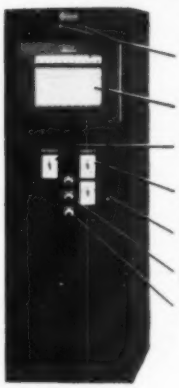
AL
LEADING PRODUCER
HIGH-ALLOY STEELS

WBD 4102 B

YOU GET *Uniform Results* with Ipsen 100% FORCED CONVECTION CONTROLLED ATMOSPHERE UNITS




Water-jacketed cooling chamber has automatic temperature control.
Sealed oil system with heating and cooling coils and 2-speed flow motor.
(Patent Pending)


1 Heat and quench signal lights
2 Automatic temperature recorder
3 Heating cycle timer
4 Quench timer
5 Hi oil flow timer
6 Selector switch for air or oil
7 Cycle start button

SIMPLE CHANGE-OVERS

Change-over from one process to another is simple, quick, and easy. Settings for heat, atmospheres, quench- and oil flow is all that is required. Cycle is then controlled automatically.

★Above is a cross-section view of the Ipsen 400 Lb./Hr. Furnace showing the advanced design features which have made Ipsen the largest manufacturer of carbonitriding and batch-type heat treating units. With these new units, you get the advantages of 100% forced convection heating and controlled atmosphere processing, *plus* the full benefits of automatic straight-through operation. Thus, you eliminate loading delays and guess-work. You control distortion and get uniform results from batch to batch . . . today, tomorrow, or next year. You eliminate blasting and pickling operations and you can often use lower grade, less costly steels.

A SINGLE UNIT HANDLES ALL OF THESE OPERATIONS

Unusually versatile, the Ipsen is built for temperatures up to 1850° F., and a single unit is equipped to handle all of the following processes:

ATMOSPHERE COOLING	OIL QUENCHING
Normalizing	General Hardening
Stress Relieving	Carburizing and Hardening
Carburizing	Carbonitriding
Carbonitriding	Martempering

Send **Samples for Free Estimate**— find out how the new Ipsen Units can be applied to your job. Samples of your work will be run, procedures established in our new, modern lab, and cost estimates given without obligation.

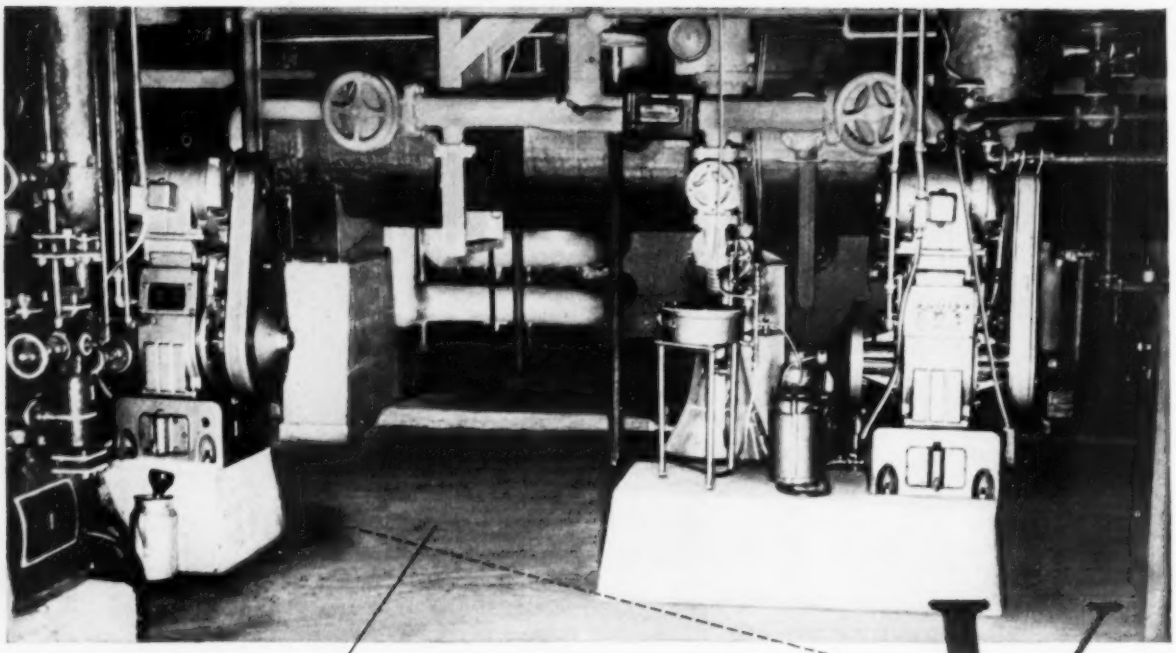
Write **for New Literature**— illustrates new design features, gives complete specifications of various units.

MORE THAN 375 IPSEN HEAT TREATING UNITS ARE NOW SERVING INDUSTRY

AUTOMATIC Ipsen HEAT TREATING UNITS

IPSEN INDUSTRIES, INC. 723 South Main Street; Rockford, Illinois

Universal Units to CARBONITRIDE • CARBURIZE • HARDEN • BRAZE • MARTEMPER • WASH • TEMPER



Stokes Microvac Pumps in machine room at Research Laboratories, Inc., St. Joseph, Mo., including diffusion type booster pump, condenser, and oil clarifier. Note relatively small size of the Stokes 8" Vacuum Valve (top-center) compared with other 6" vacuum valves at right and left.

Stokes Microvac Pumps... basic to Vacuum Processing

High volumetric and mechanical efficiency makes these famous pumps economical and reliable units in any vacuum system.

Capacities of Stokes Microvac Pumps run from 15 to 500 cfm . . . pressures to 10 microns absolute. Power consumption is low and the top-mounted motor contributes to compact design requiring minimum floor space.

Lubrication of the four moving parts (including the exhaust valve of corrosion-resistant Teflon) is fully automatic. There are no stuffing-boxes or grease-fittings, and no packing.

Parts are precision-finished, standard and interchangeable. Freedom from wear assures years of trouble-proof service.

Stokes is the only manufacturer of equipment for complete vacuum systems, including Microvac mechanical pumps, oil diffusion pumps, McLeod Gages and Vacuum Valves.

Consult with Stokes on the application of vacuum to vacuum sintering, melting, de-gassing, heat treating, inert gas purging, vacuum metallizing, and to other purposes for which vacuum deserves exploration.

F. J. STOKES MACHINE COMPANY, PHILADELPHIA 20, PA.

Send for new Vacuum Calculator for rapid slide-rule calculations. Includes standard ABCD log scale. Also send for Catalog 700, "Stokes Microvac Pumps for High Vacuum," with copious reference material.

STOKES

STOKES MAKES: High Vacuum Equipment, Vacuum Pumps and Gages / Industrial Tabletting, Powder Metal and Plastics Molding Presses / Pharmaceutical Equipment

La Salle MANUFACTURES QUALITY

COLD FINISHED STEEL BARS . . .

ROUNDS, FLATS, SQUARES, HEXAGONS, SPECIAL SHAPES LaSalle offers a complete range of cold-finished steel bars in popular sizes, shapes, and lengths. Also, special shapes to order.

COLD-DRAWN—TURNED AND POLISHED —GROUND AND POLISHED Modern drawing, turning, and grinding equipment, and skilled workmanship insure quality steel bars in standard grades.

CARBON AND ALLOY STEELS LaSalle manufactures quality cold-finished bars in AISI and SAE carbon and alloy steel grades.

FREE-MACHINING STEELS LaSalle *specializes* in free-machining steels for economical production of your parts . . . Bessemer, open-hearth, and several types of leaded steels.

FURNACE-TREATED STEELS LaSalle's furnace treatment develops elevated physical properties through quenching and tempering, and stress relieving. Careful annealing improves machinability.

SPECIAL STEELS Aggressive engineering research makes LaSalle a leader in specialty steels . . . with such developments as STRESSPROOF, LA-LED, and Super LA-LED.

Send for "The Story of Cold-Finished Steel Bars . . . from Ore to Finished Product"

La Salle STEEL CO.

Manufacturers of the Most Complete Line of Carbon and Alloy Cold-Finished and Ground and Polished Steel Bars in America.

LA SALLE STEEL COMPANY
1424 150th Street
Hammond, Indiana

Please send me "The Story of Cold-Finished Steel Bars . . . from Ore to Finished Product"

Name _____

Title _____

Company _____

Address _____

City _____ Zone _____ State _____

Johns-Manville announces the development of new **SIL-O-CEL 16L** *Insulating Fire Brick . . .*

Lompoc, California, where Johns-Manville mines and processes diatomaceous silica insulating materials

Combines outstanding physical and thermal properties for furnace service to 1600F

Check these properties of SIL-O-CEL 16L

Maximum service temperature	1600F, back-up or exposed
Approximate density	33-35 lb per cu ft
Transverse strength	60 psi
Cold crushing strength	350 psi
Linear shrinkage	0.7 percent at 1600F
Reversible thermal expansion	less than 0.1 percent at 1600F
Thermal conductivity (Btu in. per sq ft per F per hr at indicated mean temperatures)	0.92 at 500F 1.07 at 1000F 1.22 at 1500F

1—has less than 0.1% reversible thermal expansion at 1600F

2—provides high load-bearing strength

3—for direct exposure or back-up service

Here is a new development of Johns-Manville insulation and refractory research. Its exceptional characteristics provide important savings in furnace construction. Made of diatomaceous silica, Sil-O-Cel* 16L Insulating Brick is light in weight . . . has low thermal conductivity . . . high structural strength. And where furnace linings are subjected to severe heat shock or where high load-bearing properties are needed, Sil-O-Cel 16L offers outstanding performance.

Sil-O-Cel 16L is now available. Samples will be sent on request. Also available without obligation is Booklet IN-115A, which describes Sil-O-Cel 16L and other J-M Insulating Brick and Insulating Fire Brick for service to 3000F. Write Johns-Manville, Box 60, New York 16, N.Y. In Canada, 199 Bay Street, Toronto 1, Ontario.

*Sil-O-Cel is a Johns-Manville registered trade mark

Replaces SIL-O-CEL Natural Brick

The development of Sil-O-Cel 16L Insulating Brick has resulted in the discontinuance of Sil-O-Cel Natural Brick. The outstanding properties of Sil-O-Cel 16L make it the ideal replacement for Sil-O-Cel Natural Brick for back-up use. In addition, the properties of Sil-O-Cel 16L Brick extend its use to exposed service applications.

JM

Johns-Manville *FIRST IN* INSULATION

MATERIALS · ENGINEERING · APPLICATION

Which of these metals will

solve your High-Temperature problem?

Even the INCO Nickel Alloys may not provide a pat answer to that question, for strange reactions can take place when metals are exposed to high temperature corrosion.

When INCO's High Temperature Engineers do not have a known solution to your particular problem in all their amassed research information, they work with you to find it by testing the comparative durability of metals and alloys under your actual operating conditions.

First step is to write for this work sheet so that you can turn your problem over to INCO's High Temperature Engineering Service.

INCO

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.

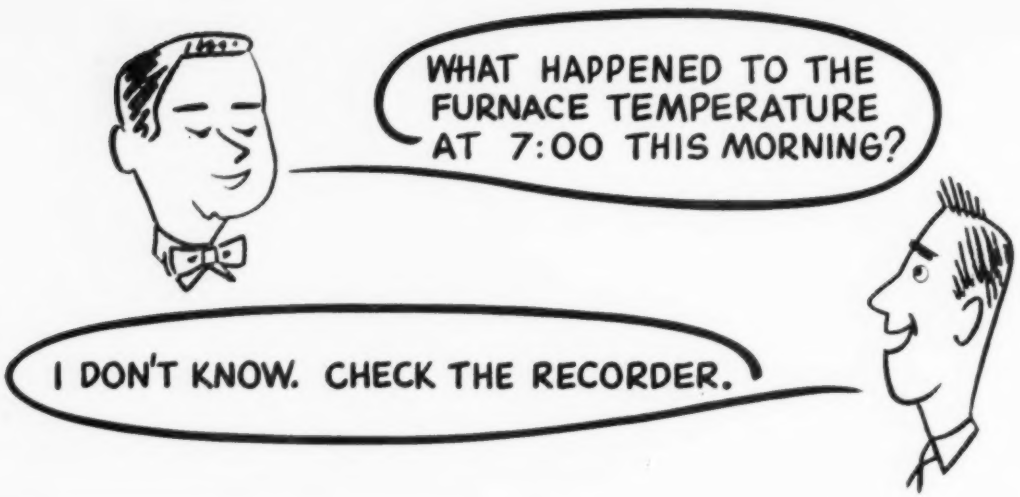
Please send me the High Temperature Work Sheet so that I may outline my problem to you.

Name_____

Address_____

City_____ State_____

MP 9-53



WHAT MAKES A RECORDER GOOD?

Many things. For instance, in the new Thermo Electronic indicating-recorder overall design is simple. The recording system only has three moving parts.

That's one thing. Here's another: the pen arm is driven from a cam. This permits linear charts to be used for almost all measurements, despite the non-linearity of the sensitive element characteristics. When warped or expanded scales are desired, special cams can be supplied.

Furthermore, nylon drive gears are used to provide long life and quiet operation.

There are many other things. If you want to hear about them, let us know. We'll be glad to supply the information. Ask for Catalog No. 60H.

AT THE ISA SHOW

This indicating-recorder, along with T-E's other pyrometric equipment, will be at the Instrument Society of America Exhibit, Sherman Hotel, Chicago, Ill., Sept. 21-25, Booth 59.

Even if everything goes the way it should with any process where temperature is involved, sometimes it's important to *prove* everything went right. On the other hand, if something is wrong, if standards aren't met, then it's very important to *know* what went wrong in order to correct it. Was it temperature? Or some other process variable?

When an accurate temperature recorder is on hand, a quick check of the record will tell you if temperature was too high, or low, and for how long. If the temperature was off, your problem is pinpointed and you can work on it right away. If it wasn't, you can go on to other variables and find the troublemaker. Either way, a good recorder is a time-saver.

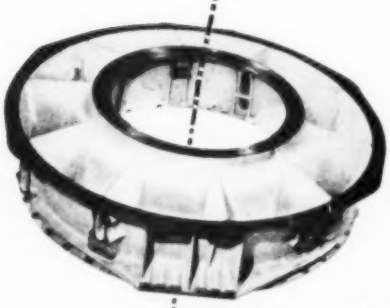
Thermo Electric makes a good recorder —it is accurate (±¼ of 1% of the range), sensitive (better than ±1/20 of 1%), durable, and can be used to record variations in temperature, humidity, solution conductivity, speed, pH, direct current, DC voltage, strain, or other variables. Both potentiometer pyrometer and resistance thermometer bridge types are available, depending on the application.

Thermo Electric Co., Inc.
FAIR LAWN NEW JERSEY

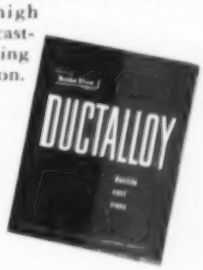
Ductalloy® castings make "impossible" parts producible

This highly stressed part secures the 7,200-lb. thrust Wright J-65 jet engine in the aircraft, carries major structural members ahead of and behind it, and mounts a main shaft bearing in its center. Air roars between the carefully contoured inner and outer rings.

As originally hogged out from an aluminum forging on an experimental basis, this part required some 1200 hours of machining—impractical for volume production. Redesigned by Curtiss-Wright Corporation's Wright Aeronautical Division as a weldment of two Ductalloy precision castings, it requires only simple turning and facing plus 25 ft. of welding to assemble the ten interconnecting stainless steel struts. An "impossible" part for volume manufacture in other metals which would meet specifications, it is rendered readily producible in Ductalloy—Brake Shoe's ductile cast iron that combines high strength with the casting and machining qualities of gray iron.



Wright J-65 jet engine main bearing support . . . impractical to machine from one piece. Readily produced as a weldment of two Ductalloy precision castings.



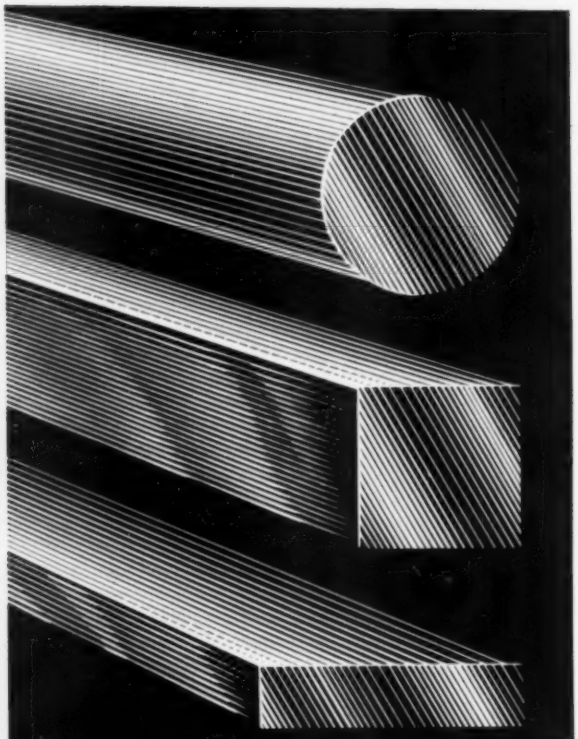
YOUR PROBLEM—Ductalloy may solve your problem if it involves economical production of complex metal shapes that are difficult to cast in steel, expensive to forge, or lacking strength in gray iron. Brake Shoe's experience, research laboratory and experimental foundry are available to help you best utilize its unusual combination of characteristics. Write for your copy of this new technical bulletin today.

Ductalloy castings are made by: BRAKE SHOE & CASTINGS DIVISION
ENGINEERED CASTINGS DIVISION

AMERICAN **Brake Shoe** COMPANY

230 PARK AVENUE
NEW YORK 17 • NEW YORK

Made from Selected Heats



"Sure-Spec"

DRILL ROD

TOOL STEEL

ALLOY BARS

These quality Sure Spec cold finished bar steels provide—

1. Increased tensile strength
2. Increased yield strength
3. Increased tortional strength
4. Increased hardness
5. Resistance to wear
6. Decreased ductility
7. Excellent machinability
8. Smooth, bright finishes

Buy Quality-
Buy Sure-Spec!

Need a safe, sturdy steel storage cabinet for your bar stock? Write for details on our low priced locked cabinet or floor rack, each holds 20 different sizes.

"for service dependable as the sun"

SOLAR STEEL CORPORATION

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General Offices: UNION COMMERCE BUILDING, CLEVELAND, OHIO

See your local classified telephone directory for our nearest office address

SALES OFFICES: Bridgeport • Chicago • Cincinnati • Cleveland • Detroit • Grand Rapids • Kalamazoo • Milwaukee • Nashville • Philadelphia • River Rouge, Mich. • Rochester, N. Y. • Toledo • Union, N. J. • Washington, D. C. • Worcester, Mass.

Starting Point For Better Melting

AJAX-NORTHRUP CONVERTER-TYPE FURNACES

20 KW. CONVERTER

STEEL

BRASS

These compact, efficient furnaces are used in all leading metallurgical laboratories, and by the major producers of precision castings.

"Almost every new alloy since 1916 started in an Ajax-Northrup furnace."

The 20 Kw. converter will melt 17 pounds of steel in 40 minutes. Maximum capacity is 30 pounds of steel, or 60 pounds of bronze. The larger 40 Kw. unit melts faster, will handle up to 50 pounds of steel. The 6 Kw. unit melts a pound of steel in 8 minutes.

All units may be used for heat-treating, forging, sintering or other applications—no problem to change from one to the other.

Ajax-Northrup converters are completely self-contained. They can be placed anywhere in your plant where water and power are available, require no special foundation or wiring — and they're certified to meet F.C.C. regulations.

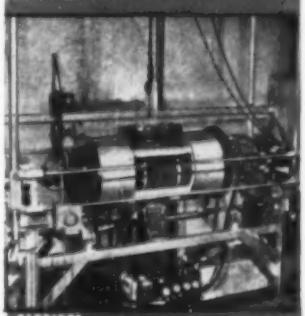
Many of today's "blue chip" industries started with a 20 Kw. Ajax-Northrup converter.

AJAX ELECTROTHERMIC CORPORATION
Ajax Park, Trenton 5, New Jersey

Associated Companies

AJAX ELECTROMETALLURGICAL CORPORATION
AJAX ELECTRIC FURNACE CORPORATION
AJAX ELECTRIC COMPANY, INC.
AJAX ENGINEERING CORPORATION

RESEARCH



CARBIDES

GOLD

AJAX NORTHRUP

INDUCTION HEATING AND MELTING

Since 1916

151

THERE'S HEAT THERE'S FAHRALLOY WHERE THERE'S HEAT THERE'S FAHRALLOY WHERE THERE'S HEAT THERE'S FAHRALLOY WHERE THERE'S HEAT THERE'S FAHRALLOY WHERE THERE'S HEAT THERE'S

FAHRALLOY...

When the PROBLEM is heat the SOLUTION is FAHRALLOY

HEAT has often been referred to as a "necessary evil" of the metal working industry. While it contributes necessary properties to metal such as in an annealing operation, heat can simultaneously work disadvantages to the conveying unit or container if, in designing that conveyor or container and determining the proper alloy, full consideration has not been given to thermal fatigue. That's where we come in! Fahralloy has no one "prescription" for the alloying and design of castings. Each problem requires its own solution, and each service condition is given complete consideration in finding the solution . . . in attaining the proper alloy. Metallurgically correct composition of Fahralloy castings assures longer life under the toughest of service conditions wherever high temperature is involved. So, when the problem is heat, you can look to Fahralloy with confidence and know that the solution is close at hand.

SEE US AT THE METALS SHOW IN BOOTH 2571

HAROLD ROGGE • 2415 Fairmont Avenue • Walnut 4303
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CLARE CHARRON • 509 Curtis Building • Trinity 5-7633
DETROIT Area Representative

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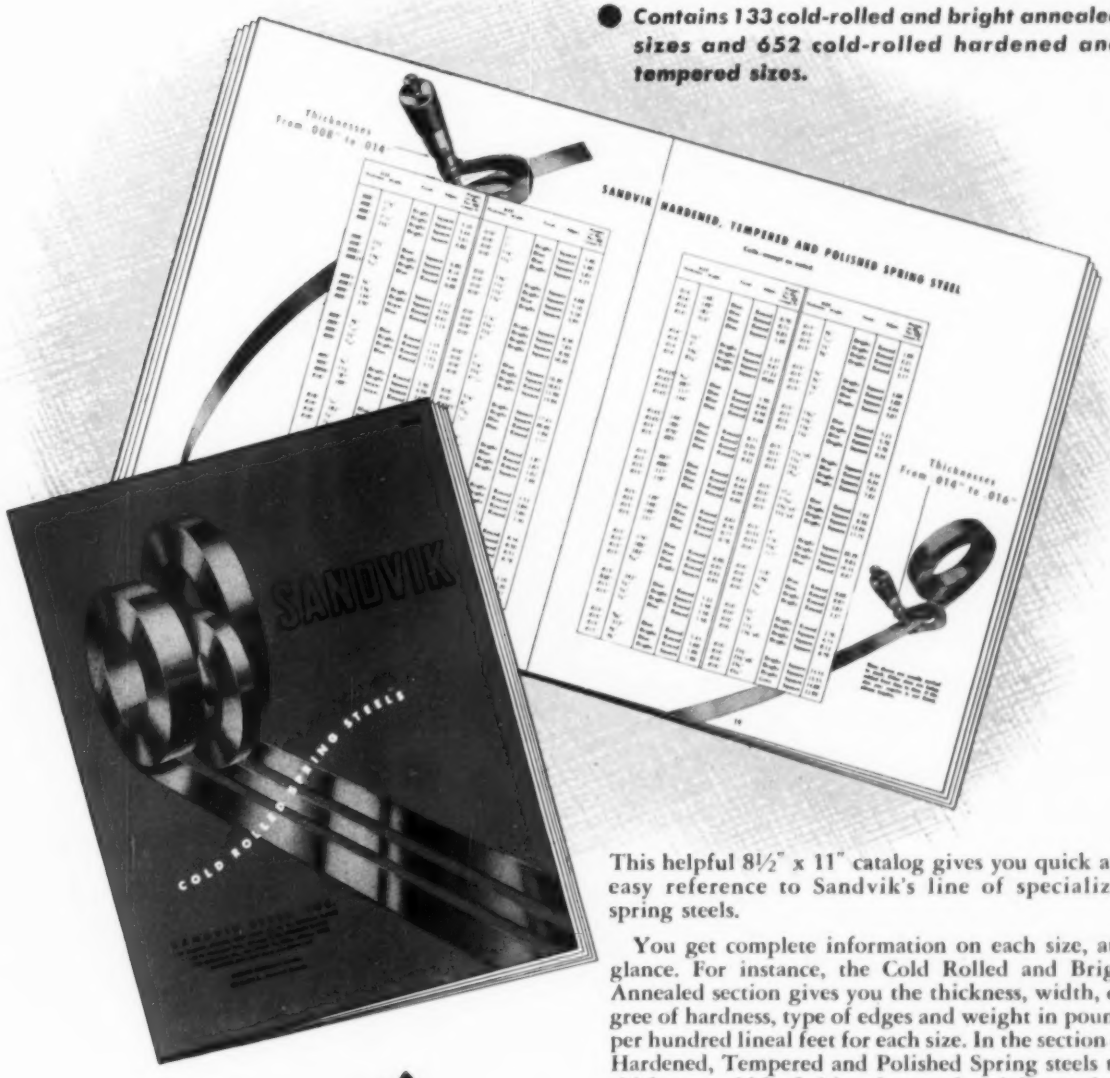
150th & Lexington Ave. — Harvey, Illinois
In Canada — Fahralloy Canada, Ltd., Orillia, Ontario

IF YOU BUY OR SPECIFY SPRING STEEL

This Free Book Belongs On Your Desk

- ***Catalogues 785 different sizes of Sandvik's specialized, cold-rolled spring steel.***
- ***Contains 133 cold-rolled and bright annealed sizes and 652 cold-rolled hardened and tempered sizes.***



This helpful 8½" x 11" catalog gives you quick and easy reference to Sandvik's line of specialized spring steels.

You get complete information on each size, at a glance. For instance, the Cold Rolled and Bright Annealed section gives you the thickness, width, degree of hardness, type of edges and weight in pounds per hundred lineal feet for each size. In the section on Hardened, Tempered and Polished Spring steels the thickness, width, finish, edges and weight per hundred feet is shown.

The booklet also includes such useful reference tables as Weights of Strip Steel, Comparative Table of Wire Gauges, Numerical Conversion Tables, Hardness Conversion Tables and a Temperature Conversion Table.

In addition, the catalog gives background information about Sandvik and the reasons behind Sandvik steel's quality. It lists some of the specialized applications for which these steels are used and tells what information to give when inquiring or ordering.

Have this complete, easy-to-use spring steel catalog at your fingertips. A note on your letterhead will bring it to you promptly and without obligation.

Sandvik Quality Steels

SANDVIK STEEL, INC.

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SANDSTEEL SPRING DIVISION • New York • Industrial Springs
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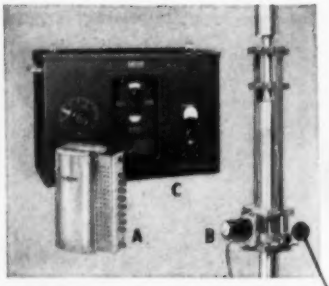
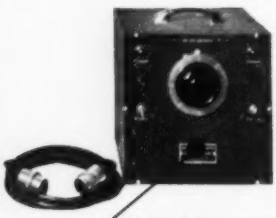
Increase the use of your Baldwin Testing machines with these accessories



High Temperature Testing Equipment

Includes electric furnace (A), high temperature extensometer (B), and temperature controller (C) which enable you to test metals at high temperatures. Various models are available for temperatures up to and including 2200° F.

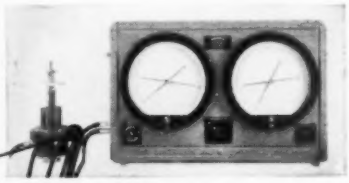


Extension Under Load Indicator

Used with a microformer type extensometer, this indicator will give you both a visual and audible signal at any desired predetermined amount of extension under load (such as 5% of the gage length).

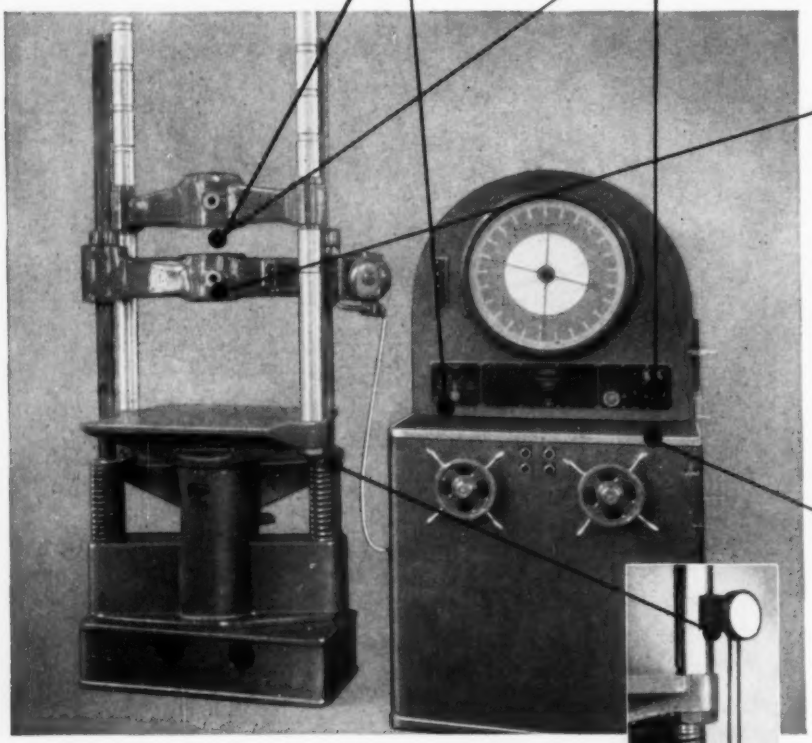
SR-4 Extensometer and Strain Gage Recorder

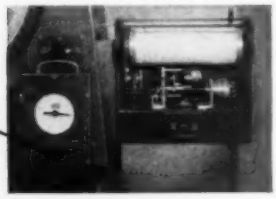
This records on a chart a load-elongation graph for determining the elastic and plastic properties of materials. Various types are available.



Air Cell (with Bourdon tube-type indicators)

Inserted in the grip slot and arranged to work with the testing machine indicator or a portable indicator, the Air Cell extends the precision ranges down to one pound full scale on any machine. This permits testing of light materials such as plastics, textiles, wood, foils, fibers, etc. with machines intended for higher capacities. (Bulletin 264.)





Strain Rate Pacer

(Shown with Microformer Recorder.) This device enables you to maintain percisely a constant straining rate of the test specimen gage length during the loading of the test specimen. Standard pacing speeds from .00025 to .25 inch per minute are available.

Ram Pacer

This controls ram speed at desired rate (8 pacing speeds, from 0.01 to 1.0 inch per minute). Enables you to meet test specifications. High magnification types for infinitely variable speeds from 0.002 to 4.0 inches per minute also available.

BULLETIN 261-A, a 12 page booklet, illustrates and describes fully Baldwin's line of grips, accessories and auxiliary equipment. Write Dept. 2324, Baldwin-Lima-Hamilton Corporation, Philadelphia 42, Pennsylvania.

BALDWIN BLH LIMA-HAMILTON

TESTING HEADQUARTERS

BALDWIN-LIMA-HAMILTON

Philadelphia 42, Pa. • Offices in Principal Cities

Cyanide Disposal Problems Minimized

by the UNICHROME Pyrophosphate Copper Plating Bath

S-M-O-O-T-H PLATING.

The fine-grained Unichrome deposit gives smoothness without the need for brighteners.

BUFFING TIME IS CUT.

If needed at all, buffing of this ductile copper takes little time, less effort.

ANODES CORRODE EVENLY.

Unichrome bath needs fewer anodes to maintain copper in solution. It keeps anodes clean and efficient.

EASILY CONTROLLED.

Unichrome Copper is stable bath, constituents are readily analyzed, has good tolerance for impurities.

ONE BATH FOR ALL JOBS.

It plates steel, zinc die castings, aluminum, intricate shapes; provides suitable undercoat for nickel, chromium; excellent stop-off for nitriding, carburizing.

Cyanide wastes *have* to be treated before disposal due to high toxicity. But installing a treating unit is expensive. So is cost of materials used.

Platers have reported spending as much as $1 for materials alone to treat each pound of cyanide waste. Add to this the cost of space required by waste treating equipment, labor costs for operating it, the high initial investment and the subsequent maintenance and you see why it all adds up to a sizable increase in plant operating costs.

The more cyanide you have, the greater this expense. But, like many other platers, you can minimize, and in some cases completely eliminate, this expense by using the Unichrome Pyrophosphate Copper Plating Solution. This bath offers greater safety because it: (1) contains no cyanide (2) is less caustic (3) has low copper concentration (4) operates at moderate temperatures.

In addition, Unichrome Copper offers outstanding advantages in operation, such as those described at left. Learn more about how this plating process can help you do better, safer plating at less cost. Write for bulletin CU-2, or discuss it with a United Chromium engineer.

UNICHROME
Trade Mark

COATINGS FOR METALS

UNITED CHROMIUM, INCORPORATED

100 East 42nd St., New York 17, N. Y. • Detroit 20, Mich.
Waterbury 20, Conn. • Chicago 4, Ill. • Los Angeles 13, Calif.
In Canada: United Chromium Limited, Toronto 1, Ont.

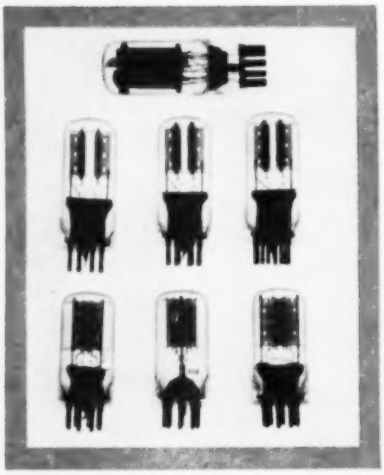
one minute

is all it takes to get finished, dry radiographs

Subject: **IGNITION CABLE ELBOW**
(Ignition cable elbows filled with insulating sealing compound.)
Objective: To confirm winding spacing alignment of center wire.
Disclosed: Gas bubbles in elbows where compound failed to fill.

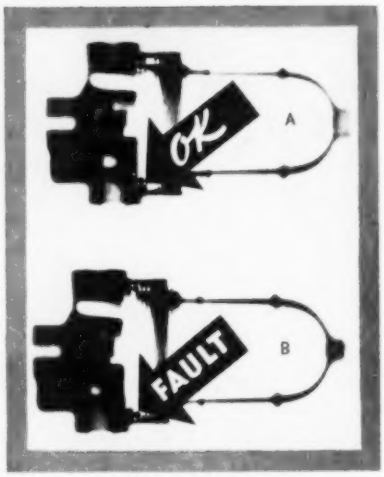
* NOTE: Reduction to 1/5 size, combined with image decay incident to the printing process, seriously degrades in these miniature reproductions the fine detail of the 10" x 10" originals.

like



Subject: **ELECTRONIC TUBES**
Objective: To confirm alignment and spacing of elements.
Disclosed: All elements correctly oriented.

these*



Subject: **CAST ALUMINUM GASOLINE FILTER**
Objective: To confirm correct placement of gasket after completion of assembly.
Disclosed: (A) Correct assembly (B) Fractured gasket slipped out of place.

with

PICKER-POLAROID

the "rightaway" radiograph

Make the exposure and get the finished, dry radiograph a minute later . . . right where you are, in *broad daylight,* if need be. Because the Polaroid x-ray packet processes itself, you don't need a darkroom, or tanks of solutions, or dryers, or even an illuminator to view it. All you need is your source of x-rays, a supply of packets, and the compact processor unit which automatically delivers the finished radiograph.

Maybe there's a place for this quick x-ray inspection method somewhere in your operation. Ask your local Picker office to help you explore your problem, or write

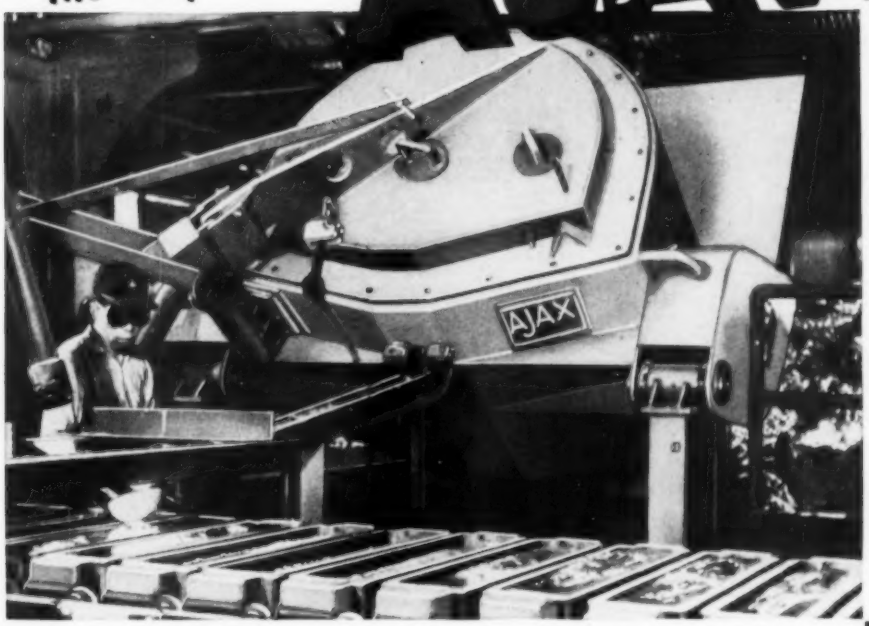
PICKER X-RAY CORPORATION
25 SOUTH BROADWAY, WHITE PLAINS, N. Y.

Picker x-ray
POLAROID

Increase Your Profits—

get the highest possible recovery of aluminum scrap with

the help of AJAX TAMA-WYATT Induction Furnaces—



AJAX induction furnaces are used in many plants for the efficient recovery of loose scrap, such as foil, chips, borings, turnings and the like. They are also adaptable for the full range of non-ferrous metals and alloys with the same advantages obtained in aluminum, and are built in sizes ranging from 20 kW to 1400 kW.

AJAX line frequency induction furnaces will melt aluminum foil scrap with the lowest obtainable melting losses. Photo above shows an AJAX 166 kW melting furnace installed at the plant of the Toyo Aluminum Works in Yao, near Osaka, Japan. Unbaled foil scrap shown at right edge of photo is remelted at the rate of about 900 pounds per hour with a recovery of over 99%. Molten metal is poured into ingot molds as shown in the front of the photo. Another view of same furnace is shown in small photo at right.

Send for Reprint of Article on Scrap Recovery by Induction Furnaces

AJAX TAMA-WYATT

AJAX ENGINEERING CORP., TRENTON 7, N. J.

INDUCTION MELTING FURNACE

AJAX ELECTRO METALLURGICAL CORP., and Associated Companies
AJAX ELECTROTHERMIC CORP., Ajax Northrup High Frequency Induction Furnaces
AJAX ELECTRIC CO., INC., The Ajax Hultgren Electric Salt Bath Furnace
AJAX ELECTRIC FURNACE CORP., Ajax Wyatt Induction Furnaces for Melting

CHASE®

free-cutting brass rod

means longer life for your tools

Chase Free-Cutting Brass rod yields short chips as it is machined. The result is much easier cutting, longer tool life. Products produced are smoother, cleaner-surfaced, less expensive to buff or polish before lacquering, enameling or plating.

Fine quality Chase rod and drawn bar are available in a wide variety of free-cutting copper alloys. They are always uniform so that repeat orders have the same cutting characteristics.

For rod and bar, for finer products at lower unit cost, call the Chase warehouse nearest you.

Chase® **BRASS & COPPER**

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The Nation's Headquarters for Brass & Copper

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Boston	Detroit	Minneapolis	Providence	
Chicago	Houston	Newark	Rochester†	(†sales
Cincinnati	Indianapolis	New Orleans	St. Louis	office only)

for **High Strength** and

Longer Life in

Farm Implements

Specify

N-A-X
HIGH-TENSILE STEEL

N-A-X HIGH-TENSILE, having 50% greater strength than mild carbon steel, permits the use of thinner sections—resulting in lighter weight of products. It is a low-alloy steel—possessing much greater resistance to corrosion than mild carbon steel, with either painted or unpainted surfaces. Combined with this characteristic, it has high fatigue and toughness values at normal and sub-zero temperatures and the abrasion resistance of a medium high carbon steel—resulting in longer life of products.

N-A-X HIGH-TENSILE, with its higher physical properties, can be readily formed into the most difficult stamped shapes, and its response to welding, by any method, is excellent. Due to its inherently fine grain and higher hardness, it can be ground and polished to a high degree of lustre at lower cost than can mild carbon steel.

Your product can be made stronger . . . to last longer . . . and in some cases be manufactured more economically, when made of N-A-X HIGH-TENSILE steel.

GREAT LAKES STEEL CORPORATION

N-A-X Alloy Division **Ecorse, Detroit 29, Michigan**

NATIONAL STEEL CORPORATION

KEEP YOUR SCRAP MOVING TO YOUR DEALER

DOW

MAGNESIUM FINDS INCREASING FAVOR AS DIE CASTING METAL

Advantages of light weight, easy machinability and competitive cost make Magnesium preferable for many types of die castings

Many manufacturers are taking a new look at magnesium as a die casting metal. In today's competitive markets, magnesium offers advantages that can't be overlooked.

Take light weight. Magnesium is the world's lightest structural metal. Where weight is a competitive factor, magnesium is the metal to use. A manufacturer of portable electronic dictation equipment found that nineteen castings in zinc weighed 13 pounds, 6½ ounces; and *in magnesium, 3 pounds, 10 ounces.* That's real weight saving!

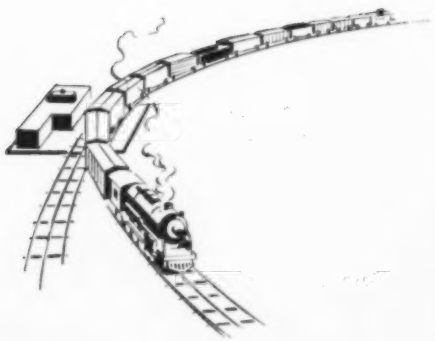
Magnesium is well known as the easiest of all metals to machine. This in itself promotes economy. As an example, the manufacturer of a lubricating machine found that the cost of machining an oil reservoir cast in grey iron was $2.05 while machining the same part cast in magnesium cost only 80¢.

Cost-wise, magnesium is better than competitive in numerous applications. One large automotive manufacturer (an industry where cost is figured on a fractional basis) has found magnesium die castings to be the lowest in cost of any metal in a score of applications. Moreover, magnesium's long-time record of price stability is also an important factor.

Now's a good time to take a close look at magnesium. For the competitive markets ahead, magnesium can offer you many advantages. Your nearest Dow office can give you up-to-the-minute information. Or write THE DOW CHEMICAL COMPANY, Magnesium Department, Midland, Michigan.

you can depend on DOW MAGNESIUM

DOW



Lionel is on the right track

Here is an Inconel pusher tray designed by ALLOY ENGINEERING COMPANY, Berea, Ohio. The Inconel basket being loaded on the tray (above) contains parts that will be sintered at 2050° F. Each tray is "double-stacked" to utilize furnace capacity.

Pusher trays, like those used at The Lionel Corporation in Irvington, New Jersey, take a two-way beating.

Here's what a daily grind those tough, oxidation and corrosion-resisting Inconel® trays go through.

First, they are loaded with two Inconel baskets holding twenty pounds of parts each. Then they start on the journey through the 1650 to 2050° F. furnace, pushing the tray behind. The furnace atmosphere is exothermic or endothermic reducing gas. They spend 35 to 40 minutes in both the pre-heat zone and the hot zone and then two hours in the cooling zone.

And they go through this cycle as many as five times a day for as long as 15 months without failure. All they require is an occasional maintenance of welds and straightening. These trays are designed and fabricated by Alloy Engineering Co., Berea, Ohio.

It is advisable to place equipment orders with your supplier well in advance of scheduled use. Distributors of Inco Nickel Alloys can supply the latest information on availability from warehouse and mill.

Write to Inco for your copy of an interesting booklet for the heat treating industry. Ask for "Keep Operating Costs Down . . . When Temperatures Go Up."

THE INTERNATIONAL NICKEL CO., INC.
67 Wall Street New York 5, N. Y.

INCO TRADE MARK

Inco Nickel Alloys

Inconel ... *for long life at high temperatures*

Buehler...

METALLURGICAL LABORATORY EQUIPMENT

. . . provides the metallurgist with the most complete line of modern designed precision machines for specimen mounting and preparation available anywhere in the world. This finely made equipment has been developed through a thorough understanding of the requirements of the metallurgist and a rigid insistance on perfection in the mechanical design and construction of each item.

Everything needed for metallurgical testing from cut-off machines, moulding presses, and grinders to the mechanical or electrolytic polishers is included in the Buehler line.

In setting up complete laboratories or adding items to present equipment the metallurgists will find in the Buehler line of coordinated equipment everything needed for producing the best work, with speed and accuracy.

Write for bulletin of new equipment or information on any specific item. We invite correspondence relative to setting up complete laboratories suitable for any particular requirement.

Exclusive U. S. agents for Amsler and Chevenard Testing Machines.

Operator using the new Model No. 1506 low speed polisher. Section of laboratory equipped with No. 1251 Duo Belt Sander—No. 1700 Electro Polisher—No. 1315 Press.

THE BUEHLER LINE OF SPECIMEN PREPARATION EQUIPMENT INCLUDES . . . CUT-OFF MACHINES • SPECIMEN MOUNT PRESSES • POWER GRINDERS • EMERY PAPER GRINDERS • HAND GRINDERS • BELT SURFACERS • MECHANICAL AND ELECTRO POLISHERS • POLISHING CLOTHS • POLISHING ABRASIVES

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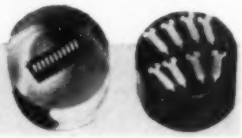

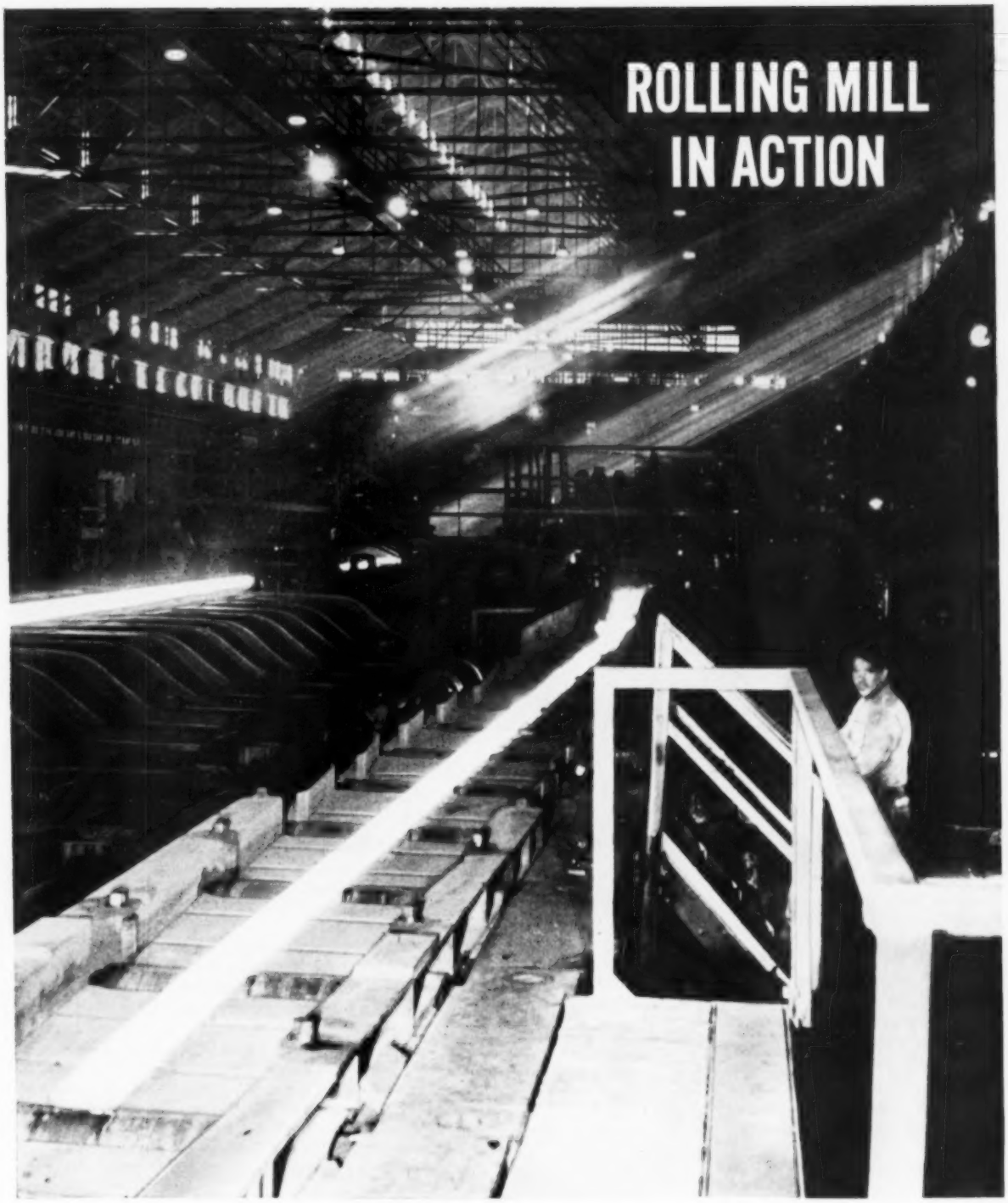

WISCONSIN STEEL COMPANY

AFFILIATE OF INTERNATIONAL HARVESTER COMPANY

INTERNATIONAL HARVESTER

180 NORTH MICHIGAN AVENUE, CHICAGO 1, ILLINOIS

*Product of Fenwal Incorporated, Ashland, Mass.

THEY'RE MADE OF BERYLCO BERYLLIUM COPPER

These Berylco parts are struts—or contact supporting members—used in Fenwal's low-temperature appliance switch.*

This appliance switch is a practical, sensitive and accurate device for controlling temperatures. In household irons, for instance, it is used to provide a range of 50 to 300°F. It maintains constant temperatures for such appliances as pasteurizers and dryers.

The qualities demanded in this application—elasticity and thermal and electrical conductivity—are such that no other material would do. It is a must that the strut return to its original shape when tension on it is released. No other material with the desired electrical conductivity can provide these deflection characteristics at the temperature involved. Thermal conductivity is also desirable—to enable the heat developed by the contact points to be dissipated.

The unique properties of Berylco—its combination of strength and conductivity, its marvelous spring properties, its endurance, its ready formability—are making better, cheaper products for hundreds of manufacturers the country over. If you would like to include Berylco in your plans for the future, we invite you to share the know-how of the world's largest producer of beryllium copper. For engineering help or sample material, call or write any of the offices listed below.

THE MOST COMPLETE LISTING of available beryllium copper forms is contained in the recently published Berylco *Product Directory*. Send for your free copy today.

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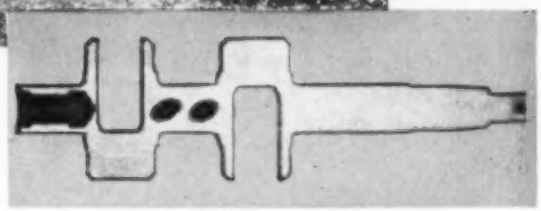
Representatives in principal world-trade centers

The Evinrude Story:

Salt bath treatment improves product . . . reduces cost in crankshaft production

Savings in machining and grinding operations, due to reduced distortion, are greater than the entire heat treating cost!

Evinrude's new Super Fastwin 15-h.p. outboard motor.



EVINRUDE CRANKSHAFT—Carburize in Park-Kase 1 for 2¾ hours at 1750°F. Case Depth .045". Transfer to Park Nu-Sal Neutral Salt at 1450°F. followed directly by Iso-thermal quench in Park's Thermo-Quench Salt.

AT Evinrude Motors, they combine Park-Kase liquid carburizing and Iso-thermal quenching and tempering into one continuous operation . . . with all processes performed in the same furnace line.

The crankshafts are immersed in Park-Kase liquid carburizer to produce the desired case . . . then transferred to Park Nu-Sal neutral salt at above the critical before the Iso-thermal treatment in Park Thermo-Quench Salt.

RESULTS: a hard case covering a tough core! Valuable production time is saved! But that's not all—

- Less distortion allows less final machining
- Metallurgical properties of part improved
- Process does not require skilled help
- Operate either manually or mechanically
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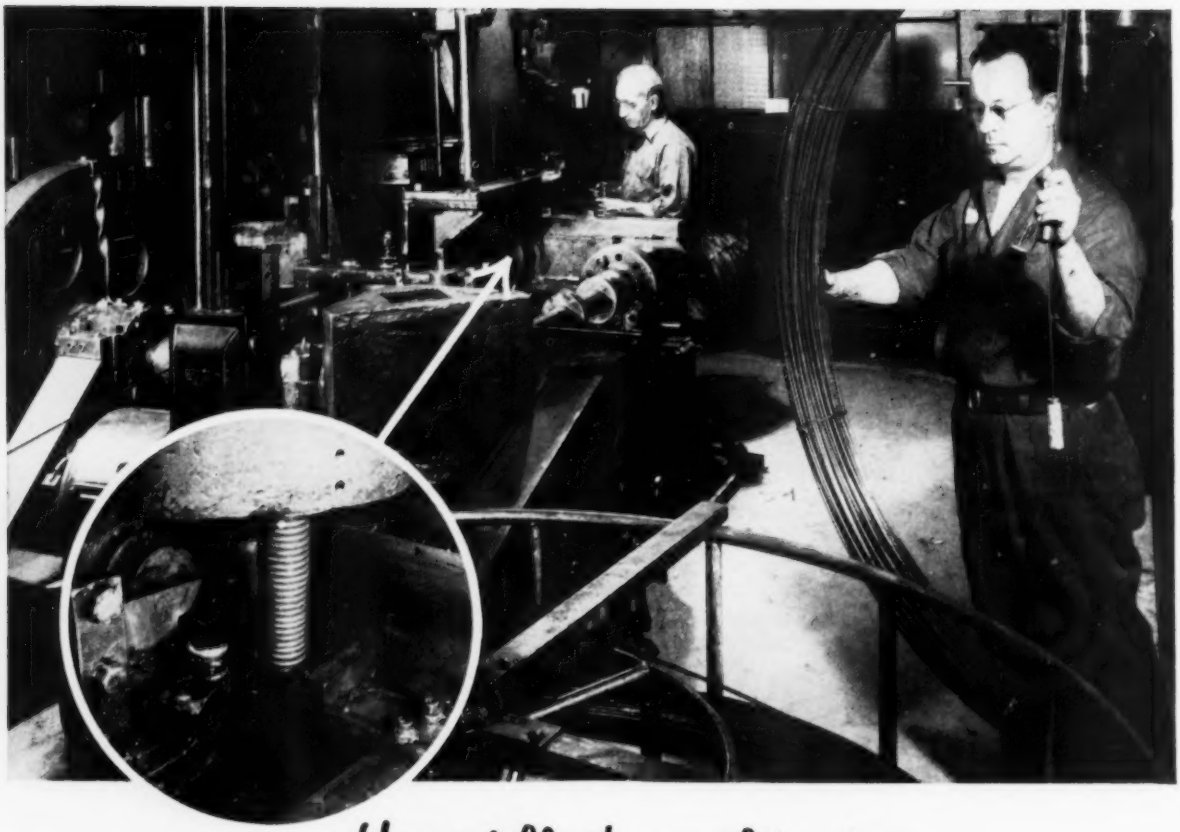

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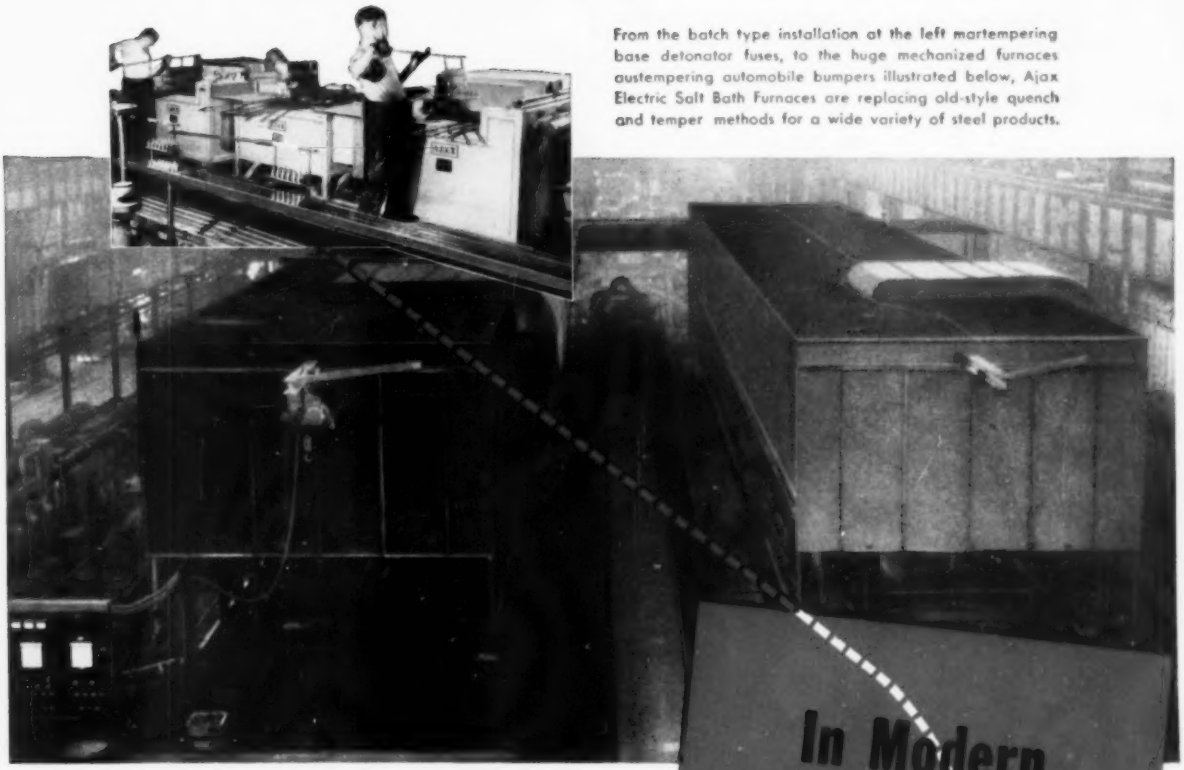

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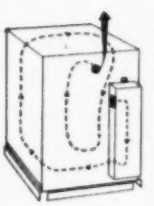

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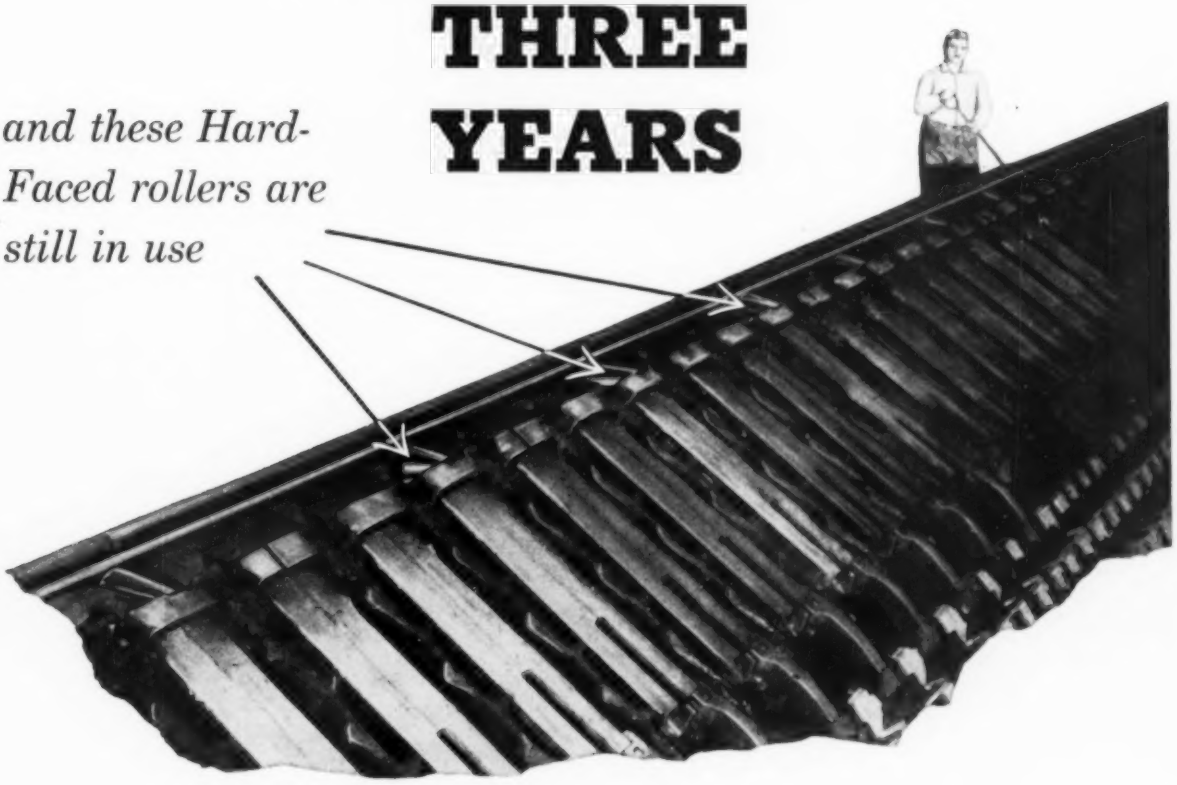

Three years ago, some cast iron cone rollers for this cooling bed were hard-faced with HAYNES alloy No. 92. Today, they are still carrying hot steel bars despite the continual impact, abrasion, and heat to which they have been subjected. Cast steel rollers on the same line, which were hard-faced with HAYNES STELLITE alloy No. 6, have also shown exceptional service — although they have not yet been in use as long as the cast iron ones.

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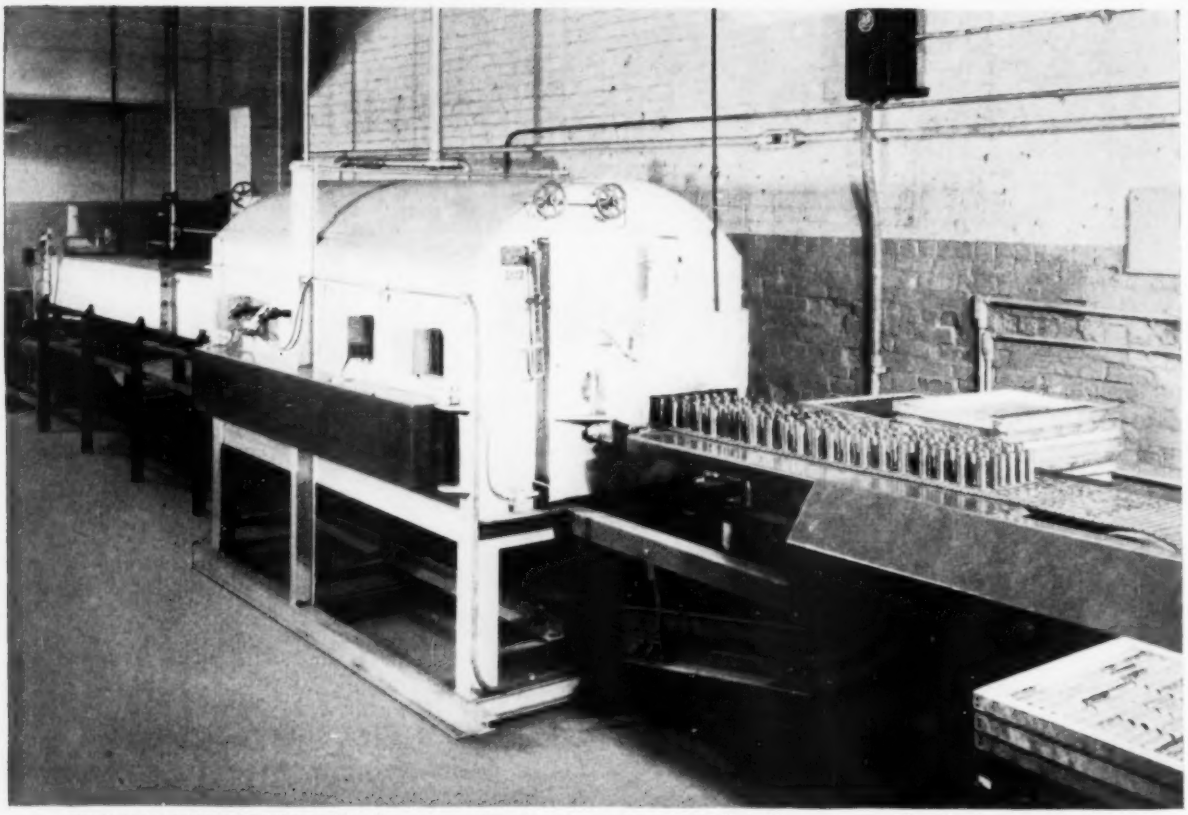

USED FOR COPPER BRAZING of hardware parts, this electric furnace was built by American Electric Furnace Inc., Boston, Mass. for Sargent & Company, well known hardware manufacturers of New Haven, Conn. The alloy conveyor belt at right runs over Norton CRYSTOLON* hearth tile in the furnace.

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The Atomic Age

New Policies on Atomic Power 73

Engineering Articles

A Test for Measuring Quench-Crack Sensitivity of Engineering Alloy steels, by R. D. Chapman and Walter E. Jominy . . . 67
Biographical Appreciation of Robert Franklin Mehl, by Hans J. Heine . . . 74
Endurance of Helical Springs Related to Properties of the Wire, by H. C. Burnett and C. L. Staugaitis . . . 77
Intergranular Corrosion of High-Purity Aluminum, by M. J. Lavigne . . . 84
Metal Finishing by High-Vacuum Metallization, by George H. Bancroft . . . 87
Units for Measuring Variations in Measurements—an Elementary Introduction to Statistics, by W. J. Youden . . . 91
Inspection Methods Keep Output of Flying Boxcars "on Target", by Arthur H. Allen . . . 97
Industrial Use of Radioactive Isotopes, by Don M. McCutcheon . . . 105
Development of Commercial Vacuum Furnaces for Melting Metals and Alloys, by James H. Moore . . . 161

Critical Points

In Praise of Old Friends 82
Ductile Iron for Hammer Castings 82
What Metals Will Throw a Spark 83
Corrosion—Do We Know Anything Much About It? 83

Correspondence

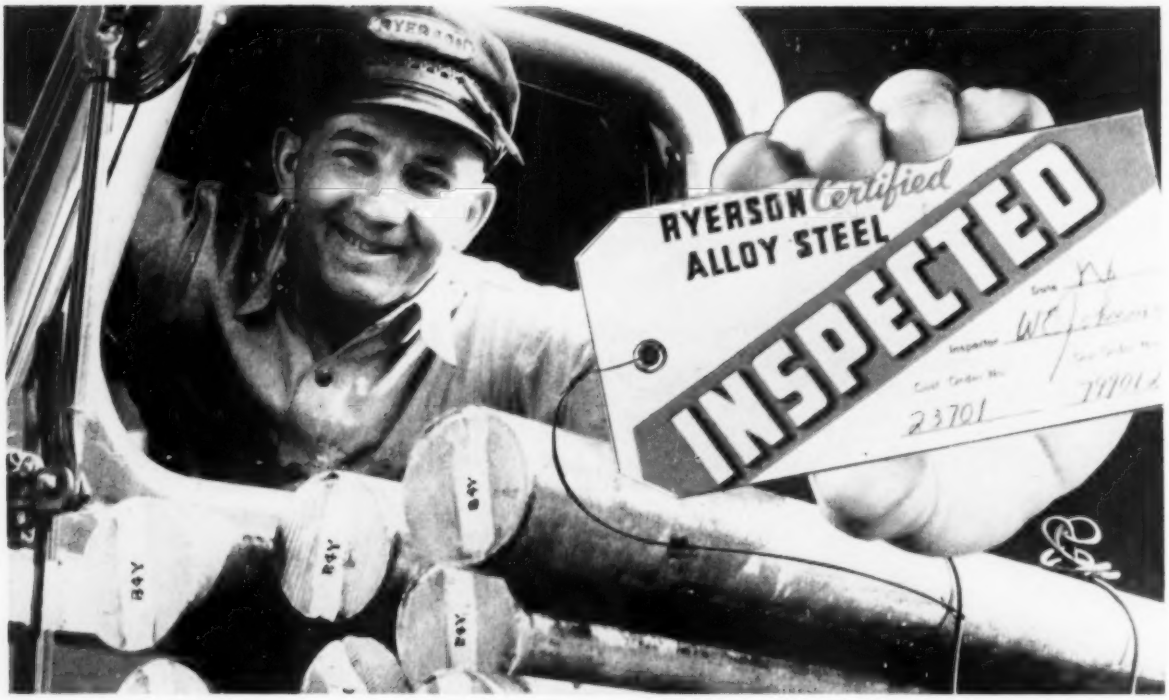
Migration of Cr and C in a Weld in Type 502, by M. A. Scheil . . . 108
Critical Points Unaffected by Magnetic Field, by B. M. Aldrich . . . 110

Digests of Important Articles

Quality Control in Copper Refining 124
Hard, Strong Ti-Fe Alloys 128
Survey of Developments in Hard Metals 132
Productivity of Die-Casting Industry 138
Sigma Phase in Heat Resisting Steels 140
Cast Furnace Resistors 166
Process of Bainite Formation 170
New Results on Oxygen in Gamma Iron 176
Oxiding—a Method of Hardening Metal 182
A Canadian View of Atomic Power 186
Permanent Magnets From Micropowders 190
Swarf Recovery 194

Departments

Data Sheet: Statistician's Table for Appraising Variability, by W. J. Youden . . . 96-B
Book Review: For the Patriotic Metallurgist; a Review by Glen C. Riegel of Pamphlet on "Boron Steels" . . . 90
Personals 112
Engineering Digest of New Products 9
Manufacturers' Literature 23
Advertisers' Index . . . . . Last page



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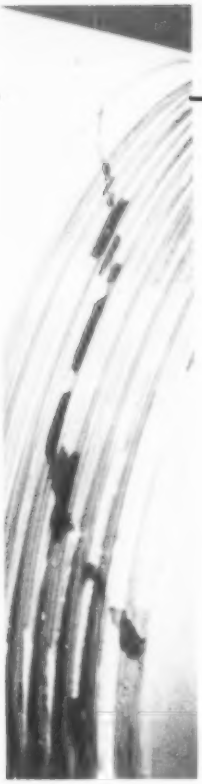


A Test for Measuring Quench Crack Sensitivity of Engineering Alloy Steels

By R. D. CHAPMAN, Research Metallurgical Engineer, Chrysler Corp., and WALTER E. JOMINY, Chief Metallurgist—Research, Chrysler Corp., Detroit*

IN THE PRESENT-DAY application of alloy steels, it is realized that maximum mechanical properties result from tempering a microstructure of 100% martensite. Tempered martensite produces the best resistance to impact and the maximum endurance limit, thus making it the most desirable microstructure in a part. However, on cooling from the austenitizing temperature two stresses result—(*a*) stresses set up by the thermal gradient and (*b*) the transformation stresses. These stresses and the changes can crack the part. Each year many pounds of steel and, what is more costly, many man-hours are lost from such quench cracking. John H. Hollomon and L. D. Jaffee, in a paper for the American Institute of Mining and Metallurgical Engineers (*Transactions*, Vol. 167, p. 601) entitled "Hardenability and Quench Cracking," stated that the cracking tendency of steel is related to the Ms temperature, although Cyril Wells, in discussing that paper, said he was unable to correlate the two.

Since there is no good test for evaluating the cracking tendency of various steels when quenched in oil, the work described herein was undertaken to develop such a test. It was desired to learn the effect of quenching temperature, quenching conditions, steel composition and other factors on tendency to quench crack.

Crackability Specimen—The authors are not aware of any test specimen which may be used to indicate cracking tendency in an oil or molten salt bath. A test piece was sought that would not be too difficult to fabricate and that would give some differentiation between engineering steels when quenched under practical conditions. This proved to be a difficult objective but we believe we have been fairly successful.

We reasoned that since cracking is due to very high internal stresses, a specimen used to study distortion—also caused by inter-

*The authors would like to express their gratitude to W. Winn, Jr. of the Chrysler Corp., and J. C. Bullen (formerly of the Chrysler Corp.) who conducted the tests described in this paper.

A "Crackability" Test Specimen

nal stresses—would be worth investigating. Accordingly, an S.A.E. 4320 steel was machined to the dimensions shown in Fig. 1A. This was gas carburized at 1700° F. to a carbon content of 0.90% at the surface in a production furnace and cooled in Sil-o-cel, after which it was heated to 1650° F. and oil quenched in a violently agitated bath. This did not crack even after refrigeration in acetone and dry ice.

We next machined specimens to the configurations shown in Fig. 1B, C, D and E, and heat treated as above. No visual cracks occurred nor could any be found under the microscope or by magnetic inspection.

We repeated the tests using an S.A.E. 4340 steel, machined to Fig. 1A, 1B, 1F and Fig. 2. Piece 1F had a narrower section than 1B, and Fig. 2 is comparable to 1F except that it has two notches in the thinnest section. One sample of each geometry was box carburized and one was used as machined. All pieces were quenched from 1650° F. into agitated oil at 80° F. The noncarburized notched specimen of Fig. 2 cracked approximately two-thirds of the way through the notch. After cold treating, the crack extended entirely through. The carburized piece of the same configuration also showed quench cracks.

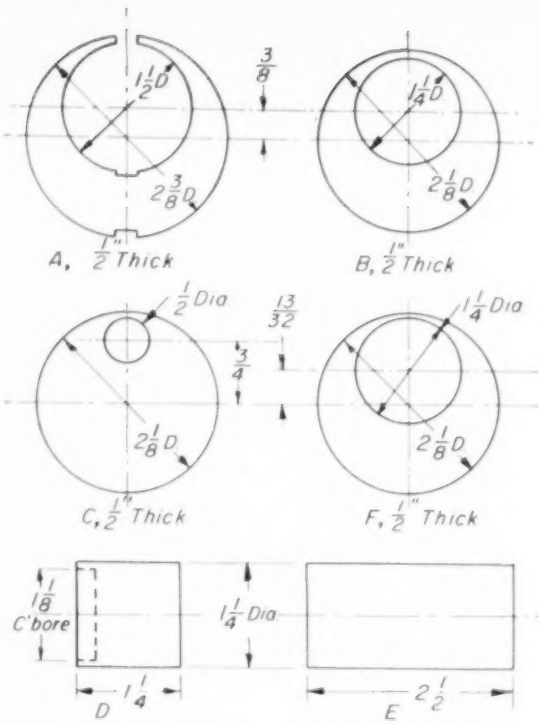


Fig. 1—Test Pieces Used in the Preliminary Work

Table I — Chemical Analyses and Hardenabilities*

Steel	C	Mn	Si	Cr	Ni	Mo	P	S	D_1	M_s
4320	0.19	0.60	0.30	0.57	1.83	0.23	0.020	0.025	4.45	725
8730	0.30	0.85	0.36	0.56	0.47	0.21	0.017	0.028	4.45	679
4032	0.32	0.72	0.23	—	0.07	0.24	0.023	0.025	1.62	727
5130	0.34	0.89	0.33	1.00	0.19	0.05	0.011	0.020	4.46	637
1030	0.34	0.79	0.31	—	0.04	—	0.022	0.027	1.06	723
1330	0.34	1.68	0.33	0.08	0.09	—	0.025	0.022	2.7	652
4130	0.32	0.53	0.31	1.09	0.11	0.21	0.016	0.014	4.40	664
4037	0.38	0.88	0.30	0.02	0.20	0.22	0.011	0.025	2.2	672
5140	0.44	0.88	0.29	0.86	0.08	—	0.019	0.032	3.78	589
4053	0.51	0.81	0.29	—	0.01	0.25	0.013	0.023	2.30	598
8742	0.43	0.88	0.26	0.45	0.64	0.28	0.027	0.035	5.9	591
4140	0.41	0.85	0.21	0.92	0.11	0.22	0.025	0.033	6.0	594
1050	0.51	0.72	0.20	0.05	0.06	0.02	0.025	0.032	1.38	611
5150	0.45	0.84	0.31	0.86	0.22	—	0.015	0.025	3.9	581
1090	0.89	0.82	0.23	—	0.10	—	0.014	0.037	1.7	361
4063	0.60	1.17	0.30	0.17	0.15	0.33	0.022	0.030	5.5	495
1060	0.57	0.75	0.23	—	0.06	—	0.014	0.033	1.26	575
4340	0.42	0.71	0.30	0.77	1.81	0.22	0.019	0.024	8.0	549
1345	0.45	1.85	0.28	0.09	0.17	0.06	0.019	0.029	4.1	563
5160	0.62	0.89	0.33	0.80	0.14	—	0.010	0.028	4.4	473
4150	0.49	0.85	0.35	1.08	0.32	0.20	0.016	0.034	8.20	525
8750	0.54	0.91	0.26	0.46	0.52	0.24	0.018	0.038	5.90	521

*D_1 (the "ideal hardenability") computed by methods given in M. A. Grossmann's "Hardenability Calculated From Chemical Composition" (*Transactions*, A. I. M. E., V. 150, p. 227, and "Metal Progress Data Sheets" No. 51 and 52). The temperature where austenite begins to transform into martensite (M_s point) is computed by methods suggested by R. A. Grange and H. M. Stewart in "The Temperature Range of Martensite Formation", *Transactions*, A. I. M. E., V. 167, p. 467.

TEST PROCEDURE

Once the specimen's shape was decided upon, several of the common S.A.E. steels were selected. Table I shows their chemistry, the calculated ideal critical diameters and Ms temperatures. These bars were received in diameters greater than 2 in. and machined into the test specimen shown in detail in Fig. 2. Measurements were carefully checked, especially the out-

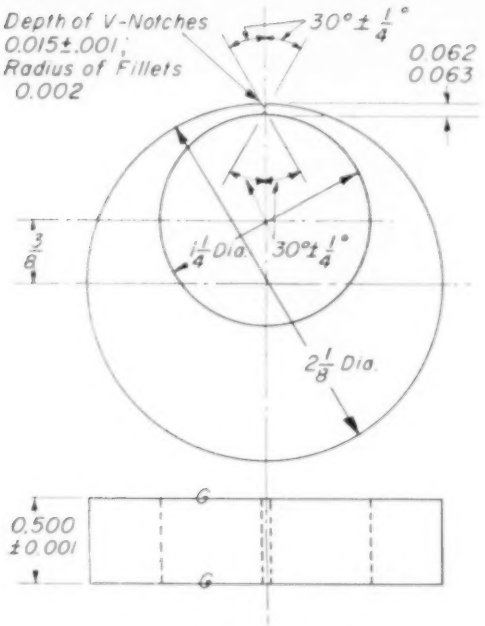


Fig. 2 — "Crackability Test Specimen" Finally Adopted

side diameters, the depth of notches as well as the radius at the root of the notch, and the thickness of metal between the V-notch. All notch measurements were made on an optical comparator to insure consistent results in the quench test.

Parts were subsequently heated to a specific temperature in cast iron chips, held there long enough to insure a uniform temperature and then quenched into either oil or salt. In quenching, the specimen was always inserted into the oil with the thin section down. During quenching, the oil was vigorously agitated by an external pump which pumped oil at the rate of 60 gal. per min. in the 30x30x30-in. tank. As soon as the test specimens had cooled to the temperature of the bath, as in oil (or to room temperature after being cooled in molten salt) they were given a rough metallographic polish across the flat faces. After polishing, the samples were inspected for cracks under the microscope at about 50 diameters. Vickers hardness readings were next taken on the heavy section and the thin section close to the notch but not in a direct path of a potential crack. Specimens were next cold treated in a mixture of acetone and dry ice at approximately —100° F. for 60 min. Specimens were again polished and examined under the microscope and the hardness measurements repeated.

Some experiments were made wherein the thickness of the test pieces was made ¼ in., ½ in. and ¾ in. The thinnest specimen did not appear to be as sensitive as the others. On the other hand, no advantage seemed to accrue to the thickest specimen. Therefore the ½-in. thickness shown in Fig. 2 was adopted.

RESULTS OF TESTS

Results from all the pieces tested are shown in Table II. Apparently, quenching from a high austenitizing temperature was more likely to form cracks than quenching from a lower temperature. In other words, quenching from 1850° F. into 80° F. oil is more apt to crack steel than quenching from 1475° F. into 80° F. oil.

Some tests, supposedly identical, cracked some specimens but left others whole. This discrepancy might be a result of variation in quenching, especially in the agitated oil where a little difference in the position of the sample in the quench tank would cause a different slip stream of the oil past the sample, resulting in a different severity of quench. All of these

Fig. 3—Magnaflux Inspection Is Widely Used to Discover Quenching Cracks (Wright Aeronautical Corp.)

Reason for Quench Cracks

inconsistent results were on the borderline; the steel was just on the verge of cracking. Some of these samples were from different heats, and J. W. Spretnak and Cyril Wells in "An Engineering Analysis of the Problem of Quench Cracking in Steel" (*Transactions* ASM, Vol. 42, p. 233) point out that two heats of the same nominal analysis may show quench cracking in one, yet not in the other.

To determine whether sulphur or phosphorus contributed to cracking, all analyses were studied, but no apparent relationship was found. (It should be noted that the phosphorus was always under 0.03% and sulphur under 0.04%.) However, presence of solid nonmetallic impurities—through their effect as stress raisers—undoubtedly contributes toward cracking susceptibility.

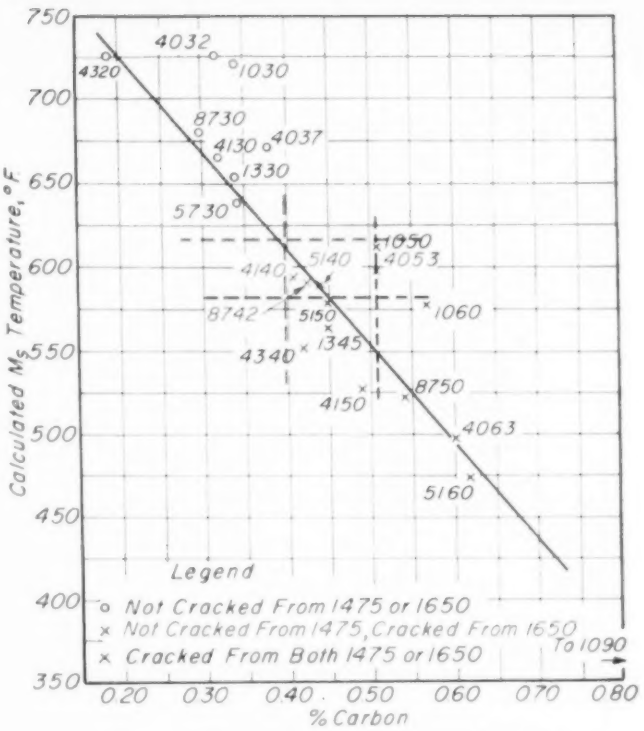
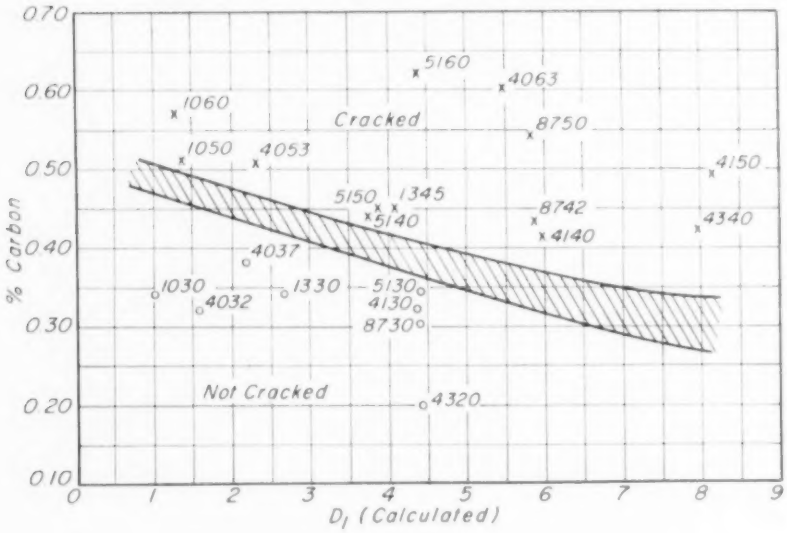

Calculated Ms Temperature, °F
% Carbon
Legend
Not Cracked From 1475 or 1650
Not Cracked From 1475, Cracked From 1650
Cracked From Both 1475 or 1650
To 1090

Fig. 4—Cracking Tendency as Related to Ms Temperature and Carbon Content when Quenched From 1475 or 1650° F.

Figure 4 plots the carbon content against the Ms temperature and cracking tendency for the various steels tested. It is well known that the Ms temperature is affected by the carbon content. The black crosses indicate that the sample cracked whereas the black circles indicate no cracks for material quenched from 1475° F. into 80° F. oil. (It is realized that many of the steels tested would not be completely austenitized at that relatively low temperature.) From such a treatment and from our specimens it will be seen that all those steels whose Ms temperatures fall below 580° F. cracked, and that any S.A.E. alloy steel with 0.50% carbon or more should crack when quenched in oil from 1475° F. Figure 4 also shows in colored crosses the same material which cracked when quenched from 1650° F. into oil. Here it will be seen that the danger point is reached when the Ms temperature is around 625° F. and the carbon content is 0.40%. Using this quench a sharper demarcation can be noted between carbon contents and Ms temperatures. Thus, quenching

Fig. 5—Effect of Hardenability and Carbon Content on Cracking Tendency When Test Piece of Fig. 2 Is Quenched in 80° F. Oil From 1650° F.



from 1650° F. is more likely to form cracks in parts than quenching from 1475° F.

This result would not be expected from the findings reported by C. E. Jackson and A. L. Christenson ("The Effect of Qenching Temperature on the Results of the End-Quench Hardenability test", *Transactions*, American Institute of Mining and Metallurgical Engineers, Vol. 158, p. 125). Their work showed that quenching from a higher temperature *decreases* the severity of quench or the "H value" of the quenching medium. Consequently, the cause of cracking must be some other phenomenon. A greater homogeneity of the austenite may result in a higher solubility of chromium or molybdenum carbides, and an austenite richer in carbon than when the material is quenched from a lower temperature. If the austenite has a higher carbon content, the Ms temperature would be depressed, which in turn would mean less ductility in the part when it reached the Ms temperature and therefore more susceptibility to cracking. Another cause could also be a greater thermal gradient between the surface and core of the material; on quenching, a shallower rim of martensite would be formed on the surface and the conductivity be such that it could not transport the heat of the core to the surface rapidly enough to prevent high thermal stresses that would result in cracking.

Rating of Quenching Conditions— The quenching conditions which are most apt to crack are relisted below in order of their severity, the most severe being at the top:

Austenitizing Temperature	Quench Medium
1850° F.	80° F. oil
1650	80° F. oil
1475	80° F. oil
1850	300° F. salt
1650	300° F. salt
1475	300° F. salt
1850	400° F. salt

The sequence of these treatments is indicated by the data in Table II in the order from left to right. For example, S.A.E. 8750 steel cracks when quenched from 1475° F. into 300° salt, but will not crack when quenched from 1850 into 400° salt. This reasoning was used to rate the various quenches.

Effect of Hardenability — Another phase that was investigated is shown in Fig. 5, where the carbon content of the steels is plotted against their calculated ideal critical diameters. It will be noted that as the carbon content increases, cracking likewise increases. This is as might be expected. It also appears that as the hardenability increases, lower carbon is necessary to avoid quench cracking. It is well known that the volumetric change which takes place when austenite transforms to pearlite is not as great as when austenite transforms to martensite; thus steels of lower hardenability which form pearlite or bainite on quenching are less susceptible to cracking than those which quench direct to martensite—that is, have high hardenability.

Relation to Temperature and Medium

Table II shows that there exists a quenching temperature and medium below which no cracking will occur in our test piece made of a particular steel. For example, the S.A.E. 4053 steel will crack when quenched either from 1850 or 1650° F. into oil; however, when quenched from 1475 no cracking occurs. By plotting these minimum values, Fig. 6 was constructed for various S.A.E. series. Those steels which are to the left are more crack sensitive; thus the S.A.E. 4300 series are more prone to cracking than the S.A.E. 4000 series; conse-

Table II — Cracking Tests on S.A.E. Steels

	Quenching Practice						
Quench. → Medium: → Temp.: →	1850 Oil. 80	1650 Oil. 80	1475 Oil. 80	1850 Salt 300	1650 Salt 300	1475 Salt 300	1850 Salt 400
4320	o	o	o	ooo	o		
8730	oo	o	o				
4032	oo	o					
5130	oo	o					
1030	oo	o					
1330	xo	o					
4130	xo	o					
4037	x	oo	oo	o	o		
5140		xx	oo	o	o		
4053	x	x	o	o			
8742		xx	xxoooo	oo	o		
4140	x	xxxo	xxxxo	oooo	oo	o	
1050		xxxx	xxxx	oooo	oo		
5150		x	xx	oo	oo	o	o
1090		x	xx	ooo	oo		
4063		x	xx	oo	o		
1060		x	xx	xoo	oo		
4340	x	xx	xx	xxxo	xoo	oo	
1345		xx	xx	xx	oo	ooo	
5160		x	x	xx	oo	o	o
4150		x	x	xx	xxo	xooo	oooo
8750		x	x	x	xx	xxo	ooooo

o = Not cracked. x = Cracked.

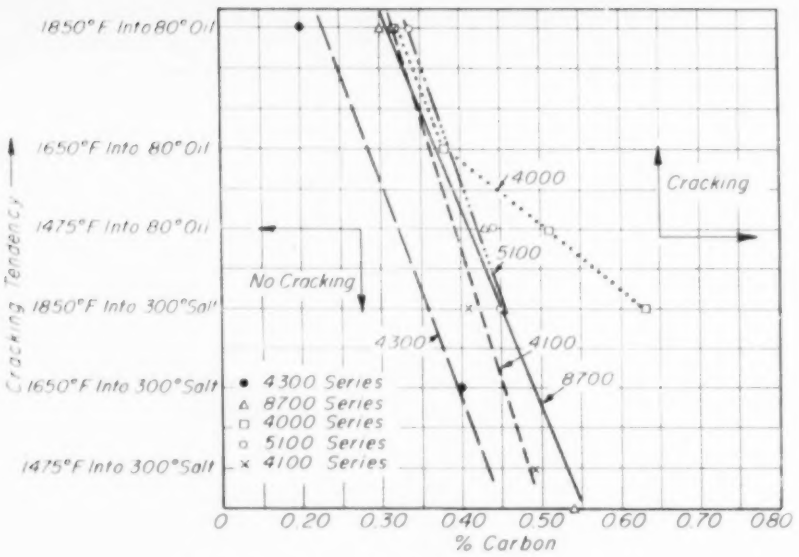


Fig. 6—Cracking Tendency Versus Carbon Content of Several Series of Alloy Steels

quently, the 4000 steels can tolerate a more drastic quench than the 4300.

It was observed that all the 0.40% carbon steel specimens that were fully hardened (all martensite) in the thin section cracked when oil quenched. However, when full hardness was obtained by quenching into molten salt none of the 0.40% carbon steels cracked. Likewise, no specimen of 0.40% carbon steel cracked, even if oil quenched, if the structure contained more than 5% bainite plus pearlite.

When the test pieces of 0.50% carbon steels of S.A.E. 8750 (D_1=5.90) and 4150 (D_1=8.20) types were quenched in salt, they cracked. This fact shows the importance of carbon, for none of the 0.40% carbon steels cracked when salt quenched. However, the S.A.E. 4053 (D_1=2.30) did not crack in salt, which shows the effect of low hardenability. It was observed during all these tests that our hardness readings of fully hardened material more closely resembled the values of Burns, Moore, and Archer's curve for maximum hardness than the curve of Hodge and Orehoski for 99.9% martensite.

CONCLUSIONS

This paper describes a test sample developed for use in measuring the susceptibility of steel to cracking when quenched from various austenitizing temperatures into oil or molten salt. Experimentation has shown that:

1. The higher the temperature from which the steel is quenched, the more likely it will be to crack. This occurs even though the H-value of the quenching medium is higher (a greater severity of quench) when lower quenching temperatures are used.

2. Cracking tendency is related to Ms temperature; the lower the Ms temperature the greater the tendency to crack.

3. The higher the carbon (up to eutectoid) the greater the tendency to crack.

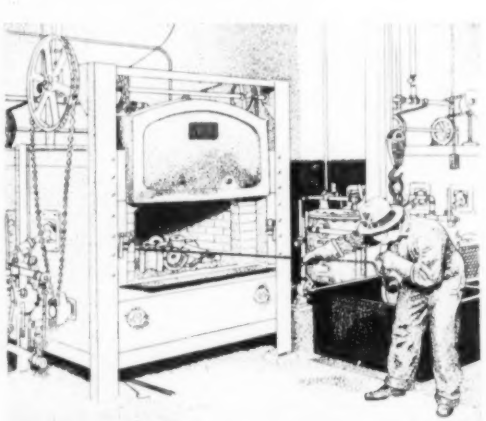
4. The higher the hardenability the greater the quench cracking tendency.

5. When hardened to 100% martensite there is more tendency to crack than when appreciably less martensite (95% or under) is produced by the quench.

6. Quenching in molten salt at 300° F. is less severe than in oil, even when 100% martensite is formed in the salt quench.

7. It has been possible to rate the relative cracking susceptibility of a number of hardening conditions.

Some of these conclusions have been surmised by previous investigators and some of them have been accepted. We feel that this work has given quantitative data to help confirm these beliefs in addition to supplying new information. It is also believed that quenching conditions which produce compressive stresses at the surfaces will help to reduce the possibility of quench cracking.



New Policies on Atomic Power*

THERE SEEMS to be no doubt that economically feasible power from the atom can be achieved. The scientists and technicians have some clear ideas as to what needs to be done. But the policy makers have not yet laid down the ground rules under which it will be done. We are a crossroads in the matter of atomic power policy.

The first technical milestone we have passed was the initial operation of a nuclear chain reactor at the "Metallurgical Laboratory" at the University of Chicago on Dec. 2, 1942, by Enrico Fermi and his staff.

Another milestone was the first successful production of useful atomic power in December 1951, in the experimental breeder reactor in Idaho, by Walter Zinn, Harold Lichtenberger and the staff of Argonne National Laboratory. More recently the homogeneous reactor at Oak Ridge has also produced useful electric power.

The third milestone occurred last summer, when reports were made by the four industrial teams which had been examining the Commission's reactor program for a year. None of them was pessimistic as to the ultimate practicability of commercial atomic power.

The fourth milestone occurred earlier this year when the prototype of an atomic power plant for a submarine began operating at the Reactor Testing Station in Idaho.

All this has combined to show us that atomic power can be produced to serve a practical purpose, and that it almost without doubt can compete with power from coal, gas and oil, and add an enormous new source of energy to the world's dwindling supplies of conventional fuels. But this vision has been clouded by the relative scarcity of "fissionable" fuel upon which power-producing chain reactions must feed. In this connection, we have now reached still another milestone in atomic energy development in this country.

There is only one fissionable fuel that occurs in nature, U^{235}, and it unfortunately constitutes less than 1% of natural uranium metal (which is 99.3% U^{238}). But the scientists have also known for a long time how to change the U^{238} into fuel by "burning" U^{235} in its presence. They have also known that they could change thorium, another relatively plentiful element, into atomic fuel by the same process. But they have never been quite sure that this fuel production process could be done in such a way that as much or more new fuel would be created as old fuel was consumed.

I now have word that [the experimental breeder] reactor in Idaho has been operated in such a way that it is burning up U^{235} and, in the process, it is changing nonfissionable U^{238} into the fissionable metal plutonium at a rate that is at least equal to the rate at which the U^{235} is being consumed. "Breeding" has been achieved!

This encouraging development must be kept in its proper perspective. It does not mean that uranium can now be regarded as a virtually costless fuel. Furthermore, a large-scale breeder reactor can be a costly proposition. It also does not mean that we are suddenly independent of raw uranium ore. Any gain in fuel through breeding is a slow process, and a reactor may operate for five years before it yields as much new fuel as was initially invested in it.

The real significance of breeding is that it is now possible for mankind ultimately to utilize *all* of the uranium that can be extracted from the earth's surface for atomic fuel, whether it is fissionable or not in its natural state. It also suggests that thorium may also ultimately be utilized. All these factors, and a great many more besides, have combined to bring us to the crossroads in atomic power policy that we have now reached.

The last remaining *technical* obstacle is to learn how to build atomic power plants so cheaply that the power they produce will be competitive with that from conventional fuels. The *policy* problem that faces us is to determine how this cost-cutting job can best be done.

The Atomic Energy Act of 1946 gives the Commission a complete monopoly. No one may own fissionable material nor any facility in which such material is produced. No one may own a patent having to do with the production of fissionable material. The Commission also has complete control of all information that may be developed in the field of atomic energy.

But now, the Commission feels, the law should be modified so that people outside of the Government be given a chance to work toward reactors to meet civilian demands. The job ahead is a developmental and cost-cutting one—a job that can be done best by competition among skilled people working toward the same goal.

To accomplish this we have proposed to the Joint Committee on Atomic Energy of Congress that the present law be amended to permit (*a*) the ownership and operation of nuclear power facilities by groups other than the Commission; (*b*) the lease or sale of fissionable material; (*c*) the use and transfer of fissionable or byproduct materials by the owners of reactors; (*d*) the granting of more liberal patent rights; (*e*) liberalized information in the power reactor field; (*f*) research and development work by the Commission in the power field as is warranted in the national interest; (*g*) a progressively adjusted safety code to keep pace with operational experience with reactors. All the above to be regulated by the Commission in the interest of national security, health and safety.

Our purpose is to create an environment in which developmental effort toward commercial power from the atom can be expected to go forward.

*Verbatim extracts from address by Gordon Dean, chairman of the U.S. Atomic Energy Commission, before Edison Electric Institute, June 4, 1953.

Metal Progress's Biographical Dictionary

Robert Franklin Mehl

Eminent Educator • Distinguished Metallurgist

If the question were raised as to who made the earliest application of modern physicochemical science to metallurgical problems and therefore has contributed many of the basic ideas now current in physical metallurgy, who has led in the introduction of science into the descriptive courses formerly monopolizing metallurgical education, the answer would be unanimous: Robert F. Mehl, dean of graduate studies, head of the department of metallurgical engineering, and director of the metals research laboratory at Carnegie Institute of Technology in Pittsburgh.

As the certificate for the American Society for Metals' Gold Medal so aptly states, metallurgy of today would be far different if it had not been for the influence of men like him, an influence exerted perhaps even more strongly through his students than through his personal contributions.

Robert Franklin Mehl was born in 1898 in Lancaster, Pa., where he graduated in due time from Franklin and Marshall College in chemistry. He later received a Ph.D. in physical chemistry from Princeton. After a few years of teaching as a Proctor Fellow in Chemistry at Princeton University, as head of the department of chemistry at Juniata College, and as a National Research Fellow at Harvard University, he became superintendent of the division of physical metallurgy of the Naval Research Laboratory in 1927. His position here "brought about the complete switch in my career from physical chemistry to metallurgy," to quote his own words.

After four years in Washington he moved to Middletown, Ohio, becoming assistant director of the research laboratories of the American Rolling Mill Co., but gave up this position in 1932 to join the faculty at Carnegie Tech, a position especially attractive since it gave him the opportunity to organize the metals research laboratory. His influence on the campus has steadily increased, as more and more of his associates came to recognize his extraordinary breadth of vision. As this is written comes the news of his appointment to the post of "Dean of Graduate Studies"—engineering, science, fine arts, humanistic and social studies.

The record of Bob Mehl's achievements in metallurgy alone is long. His publications include some 150 papers devoted primarily to the constitution of alloys, crystal structure, radiography, aging of iron and steel, the transformation of austenite, metallic diffusion, recrystallization, and—what is more fundamental—the processes of nucleation and growth. In addition, Dr. Mehl translated Professor Tamman's book on "The States of Aggregation", has written a book on the history of physical metallurgy, and has published the only book extant in Portuguese on the metallurgy of iron and steel.

Dr. Mehl has received numerous medals and citations. The Institute of Metals Division of the American Institute of Mining and Metallurgical Engineers awarded him certificates for the best scientific paper published in its *Transactions* for 1934, 1939, 1943, 1944, and 1947—five times! This Institute also awarded him the Douglas Medal in 1945. The John Scott Medal for the development of gamma-ray radiography was awarded him by Directors of the Board of City Trusts of Philadelphia in 1934, and the Howe Medal of the American Society for Metals was his in 1939. Honorary doctorates came from Franklin and Marshall College, Stevens Institute of Technology, Colorado School of Mines, and the University of Sao Paulo in Brazil. Announcement has just been made that he will receive the Francis J. Clamer Medal of the Franklin Institute on Oct. 21.

Dr. Mehl has given innumerable special honorary lectures such as the Campbell Memorial Lecture, the Institute of Metals Annual Lecture, and the Hatfield Memorial Lecture for the Iron and Steel Institute of Great Britain.

In 1944, Dr. Mehl went to Brazil at the request of Nelson Rockefeller, then Coordinator of Inter-American Affairs, to give a series of lectures on iron and steel at the University of Sao Paulo and to consult with Brazilian industrialists. This led to subsequent visits to South America, particularly for the United States State Department in connection with the "Point Four" program.

Postwar 1945 found him in England, France and Germany for the Technical Intelligence Investigation Committee. In connection with this scientific "intelligence" he inspected the wartime work of the Kaiser Wilhelm Institute fur Eisenforschung and other groups in Germany. In 1948, he lectured in England and in Sweden and surveyed metallurgical research in those countries.

He married Helen Charles in 1923 and has a son and two daughters. His son, Robert F., Jr., teaches English in New York State. His

older daughter, Marjorie, is married and has a very successful fashion program on a local Pittsburgh television station. His younger daughter, Gretchen, is now a student at Cornell University.

While somewhat reluctant to discuss his hobbies, Bob admits to being an amateur painter and of having been an ardent tennis player. His single-mindedness is illustrated by the fact that he once broke his wrist on the courts and then trained himself to handle the racquet with his left hand. Eventually he was a double-threat!

According to his associates at Carnegie Tech, no job in hand is unimportant or unworthy of intense interest to Dr. Mehl, whether it is a major research problem or a five-minute address to a group of college freshmen. Not narrow in his interests, Dr. Mehl keeps himself well informed on all scientific subjects. He is a voracious reader and gets ideas constantly from other fields, a practice well worthy of emulation by his students. Brilliant himself, with uncanny ability to grasp a problem in a hurry, he is always springing something new on the men around him. That he is not an anchorite is attested by a long list of professional activities. He organized the Minerals and Metals Advisory Board for the National Academy of Sciences and was its first chairman. To quote from the Gold Medal Citation, "Those who have had the pleasure of serving on this Board under Mehl's leadership, can attest to the fact that he is not only an outstanding metallurgist but a competent organizer and capable leader."

Seated in his comfortable and dignified office in Engineering Hall, I questioned Dr. Mehl. "What subject is most dear to your heart?" He said, so quickly that there was obviously no doubt in his mind, "Why, these day-to-day associations with my students." Having studied under him myself, I can wholeheartedly testify as to his enthusiasm, meticulous preparation and forceful presentation of any subject.

Carnegie Institute of Technology is not a factory following a standard line of "Groupthink"; its faculty was the first to have the vision and foresight to modernize the metallurgical curriculum completely. Dr. Mehl keenly feels the importance of research to training of good students. Two types of research, practical and fundamental, should be carried out so the university may be most useful to industry and it is interesting to note that he himself has directly contributed to the practical field, as in the development of the highly successful method of gamma-ray radiography.

He knows that universities are having a very difficult time financially these days and with singular dedication he devoted much of his energy to an effort to attract good men to the faculty and keep them there. Personnel work is a highly competitive game, and industry provides the most severe competition. Yet special attention must be given, says Mehl, to ways and means to attract the ablest young men to university work, for these young teachers, through their students, will improve the quality of the whole metallurgical profession. He therefore heartily endorses those industry-endowed professorships in Carnegie's faculty, and is glad to note that all the American technical societies are taking more of an active interest in metallurgical education. He was the first chairman of the ASM Educational Advisory Committee, and has given advice and counsel on many of the Society's educational projects. It remains for industry, in his opinion, to protect the health of the American universities. As the universities are strong, so will America be strong.

As to future plans, Dr. Mehl has but one—to be a college professor and an outstanding leader of graduate work. When I spoke to him, he had just returned from a three-day lecture tour, wherein he gave four addresses on different subjects, in addition to a bit of consultation and an informal talk to a meeting of the Royal Canadian Institute in Toronto. He said, "One of these days perhaps I will retire to the relative peace and quiet of industry!"

Immediately following our interview, we attended a graduate seminar which the Department of Metallurgical Engineering holds every week and listened to a discourse on "A Dislocation Mechanism for the Growth of Deformation Twins in Crystals" by one of the graduate students. Needless to say, Dr. Mehl followed the discussion with keen interest and asked the most searching questions himself. This is advanced education at its best.

This inadequate account may best be closed with the words of the certificate accompanying the Gold Medal of the American Society for Metals: "For outstanding metallurgical knowledge and great versatility in the application of science to the metallurgical industries as well as exceptional ability in the diagnosis and solution of diversified metallurgical problems." All in all, Bob Mehl's no stuffed shirt, but a friendly man whose enormous abilities are little suspected until he gets into action.

HANS J. HEINE

By H. C. BURNETT
and C. L. STAUGAITIS
Metallurgy Division
National Bureau of Standards
Washington, D.C.

improve the performance of springs, the Ordnance Corps, U.S. Army, has sponsored a research program on the fatigue properties of music wire and springs made therefrom at the National Bureau of Standards. The following reports a study, made under the direction of J. A. Bennett, chief of the mechanical metallurgy section, of the correlation between the fatigue properties of music spring wire as determined by reverse bending tests and the fatigue properties of helical compression springs wound from this wire. If an accurate correlation were found to exist, it would provide a relatively simple method of testing the quality of wire

Endurance of Helical Springs Related to Properties of the Wire

SPRINGS PLAY a very important part in the continued operation of many machines and mechanical devices. Music wire has long been recognized as being one of the best types of wire for coiling springs which must withstand high fluctuating stresses. All too frequently, however, engineers lack adequate information concerning the fatigue life of springs—especially at high stress levels. While the fatigue life of wire in reversed bending may be determined quite rapidly, it is a slow and somewhat difficult task to determine accurately the life of wire after it has been coiled into a spring and stressed in torsion as it is in service.

Therefore, as part of a broad program to improve the performance of springs, the Ordnance Corps, U.S. Army, has sponsored a research program on the fatigue properties of music wire and springs made therefrom at the National Bureau of Standards. The following reports a study, made under the direction of J. A. Bennett, chief of the mechanical metallurgy section, of the correlation between the fatigue properties of music spring wire as determined by reverse bending tests and the fatigue properties of helical compression springs wound from this wire. If an accurate correlation were found to exist, it would provide a relatively simple method of testing the quality of wire that is to be used for manufacture of springs.

Anticipating our conclusions, it may be said that we found such a correlation to exist, and we have been able to propose a reasonably accurate method of estimating the fatigue properties of short helical springs from the easily determined bending fatigue properties of the wire from which they were made.

Numerous investigators have reported data on the fatigue properties of small steel wires★, but the material tested has usually not been drawn as severely as music wire.† Relatively little has been reported concerning the relation of the fatigue of the wire to that of helical springs made therefrom, although a paper by

★"The Rotating-Wire Arc Fatigue Machine for Testing Small Diameter Wire", by J. N. Kenyon, *Proceedings*, American Society for Testing Materials, Vol. 35, 1935, p. 156.

"Some Aspects of the Fatigue Properties of Patented Steel Wire", by E. T. Gill and R. Goodacre, *Journal*, Iron and Steel Institute, Vol. 11, 1934.

"Fatigue Properties of Steel Wire", by S. M. Shelton and W. H. Swanger, National Bureau of Standards *Journal of Research*, Vol. 14, Jan. 1935, p. 17.

†EDITOR'S FOOTNOTE—The reader might well look into a fascinating book by Kenneth B. Lewis entitled "Steel Wire in America". There he will find that "music wire" or "music spring wire" is made from meticulously refined, eutectoid carbon steel. The hot rolled wire rods are first "patented" by austenitizing at about 1500° F. and quenching in a lead bath at about 1000° F. (just below the nose of the S-curve), thus transforming into a very fine pearlite ("sorbitic structure"), Rockwell C-41 or 42 hard. After cleaning of scale, such patented rods are cold drawn through a series of dies of diminishing sizes so graded that the strength of the wire will be increased by cold work to upwards of 800,000 psi.

Spring Testing Methods

O. G. Meyers in *Machine Design* for November 1951 ("Working Stresses for Helical Springs") touches on this question.

Four commercial samples of music wire were tested for fatigue in reversed bending in two types of testing machines, namely, the Hunter wire fatigue testers and a machine designed and constructed at National Bureau of Standards.

Table I – Study of Dispersion of Bending Fatigue Tests

	WMA	HMA	WMC	HMC
Diameter	0.039	0.039	0.053	0.053
Stress	150,000	150,000	125,000	125,000
Cycles to failure				
Minimum	21,900	11,500	34,900	43,500
Maximum	58,200	61,900	200,200	138,600
Median	37,700	32,688	128,900	95,000
Arithmetic mean	37,400	33,180	125,236	89,784
Standard deviation	7,773	11,274	43,678	26,164
Coef. of variation	20.8%	33.9%	34.8%	29.8%

The Hunter machines (described fully by F. A. Votta, Jr., in *Wire and Wire Products* for December 1948) rotate the wire specimen while it is held in a U-shape. Our machine, shown in Fig. 1, is of the rotating strut type, but differs somewhat from other machines of this type. One end of the specimen is fixed in the chuck attached directly to the motor and the other end is held in a brass collet mounted in a ball bearing. The tailstock bearing is also free to rotate about a horizontal axis normal to the specimen. Flexure plates A in Fig. 1, on the columns supporting the tailstock bearing, allow the bearing to move longitudinally with a minimum of friction. The force exerted by the curved specimen is transmitted to a load measuring device B, between the tailstock bearing and the loading screw C. This dynamometer is a U-shaped aluminum alloy member with wire strain gages mounted on the inside and outside of the bottom of the U at E. After calibration by dead-weight loading this instrument was found to be accurate within 0.01 lb. for a range up to 8 lb.

The bending moment at the center of the wire is calculated from the axial load and the vertical deflection of the specimen. In order to avoid any bending moment at the ends, which would invalidate the calculations, the curve of the specimen must be symmetrical about its center, a condition which is met by setting the angle at the motor end of the specimen equal to that at the tailstock by means of the protractors D (Fig. 1). The maximum bending moment is then given by

$$M = PY$$

where P = applied load at the end of the wire in pounds, and Y = deflection of the center of the wire in inches.

The maximum stress is

$$S = PYd \div 2I_p$$

where d = wire diameter in inches, and I_p = polar movement of inertia = $\pi d^4 \div 64$.

The fatigue tests of short★ compression springs were made in another machine designed and constructed at the National Bureau of Standards. It is shown in Fig. 2. The motor and the adjustable eccentric from a Krouse plate-bending machine were utilized; eight springs could be tested simultaneously, four each at two stress levels. Stress ranges were computed by measuring the change in pitch of the spring with a cathetometer when it is held in the no-load, minimum-load, and maximum-load positions.

The formula for calculating the stress is as follows:

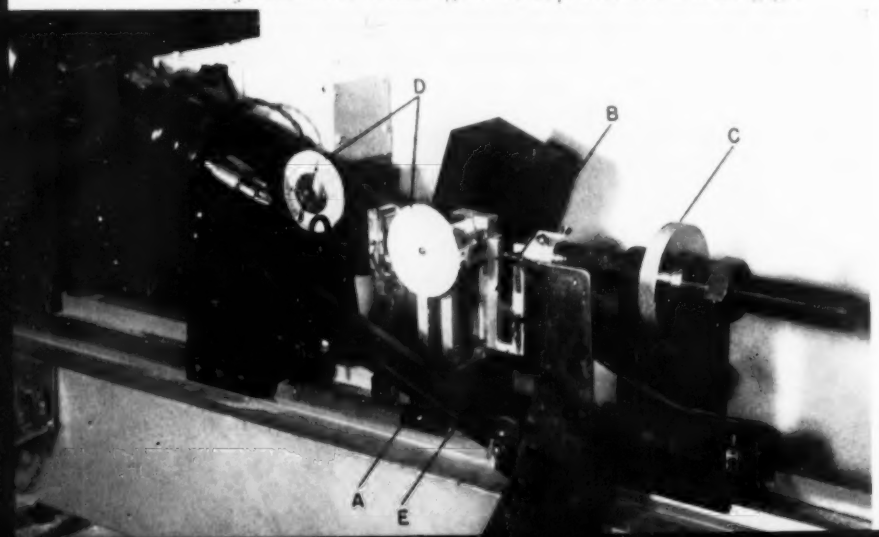
$$S_s = GdFK \div \pi D_m^2$$

where S_s = nominal shear stress in psi.

G = torsional modulus of rigidity (11.5×10^6 psi. for steel wire)

★A spring is classed as "short" if it can be compressed to solid height between parallel plates without buckling.

Fig. 1—National Bureau of Standards' Wire Fatigue Testing Machine Showing Strain Gage Dynamometer. A, flexure plates; B, dynamometer; C, loading screw; D, protractors; E, strain gages



F = deflection per coil in inches
K = Wahl correction factor
d = wire diameter in inches
D_m = mean diameter of the spring in inches.

Samples of music wire, 0.039 and 0.053 in. diameter each, from two sources of supply were investigated. For the reverse bending tests the wire was cut into 6-ft. lengths and straightened by the Hunter Spring Co.

Test springs were wound directly from the coil on a Perkins precision spring-coiler at the National Bureau of Standards. Code marking and tensile strengths are as follows:

Code	Diameter	Tensile Strength
WMA	0.039 in.	326,000 psi.
HMA	0.039	376,000
WMC	0.053	314,000
HMC	0.053	376,000

Approximately 50 specimens of each type of wire were tested in the Hunter machine at stress amplitudes of ± 200,000 psi., 170,000, 125,000, and at several stresses near the fatigue limit. About double that number were also tested in the N.B.S. machine at stress amplitudes ranging from 300,000 psi. to below the fatigue limit. (Because the stress could not be determined exactly until our machine was in operation, tests in it were not limited to a few stress levels, as were those in the Hunter machines.) No consistent difference was noted in the results from the two machines.

Figure 3 plots the 152 fatigue tests made in reversed bending on the 0.039-in. HMA wire in the two machines.

In order to determine the dispersion of the results more precisely, 25 additional specimens of each type of wire were tested in the Hunter machine. Standard deviation and coefficient of variation were determined by methods outlined in "A.S.T.M. Manual on Presentation of Data." Results are summarized in Table I.

The dispersion as determined by the tests on HMA wire at 150,000 psi. is indicated by the large circle in Fig. 3, where the horizontal diameter covers a range from one standard deviation below the mean to an equal distance above.

Referring again to Table I, the coefficients of variation of the WMC and HMC wires may not be directly compared with those of the WMA and HMA wires, due to the differences in wire diameter and stress amplitude of the tests. However, the marked difference between WMA and HMA 0.039-in. wire may well be explained by a large number of surface defects formed during the drawing operation, and existing throughout the coil of HMA wire. Examples of these defects are shown in Fig. 4.

Figure 5 shows a type of surface defect not attributable to the drawing operation but one

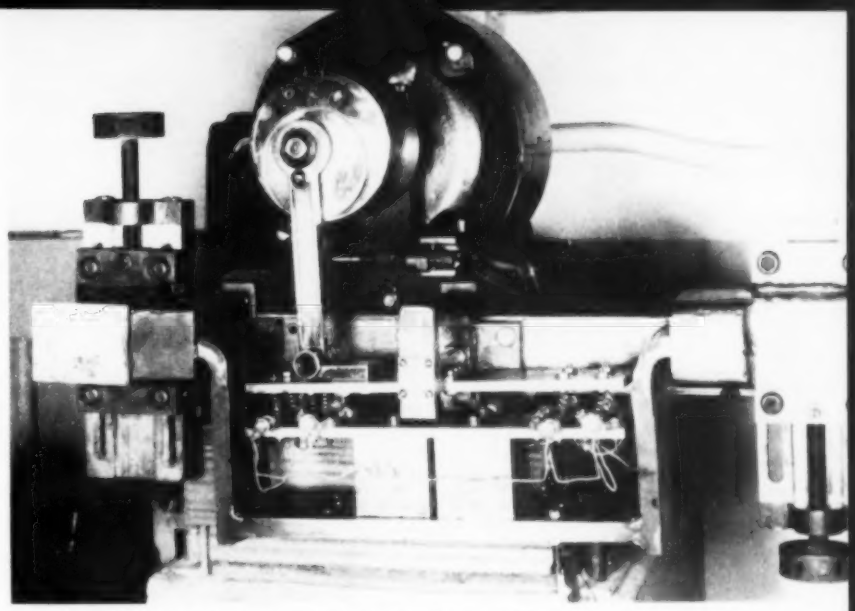
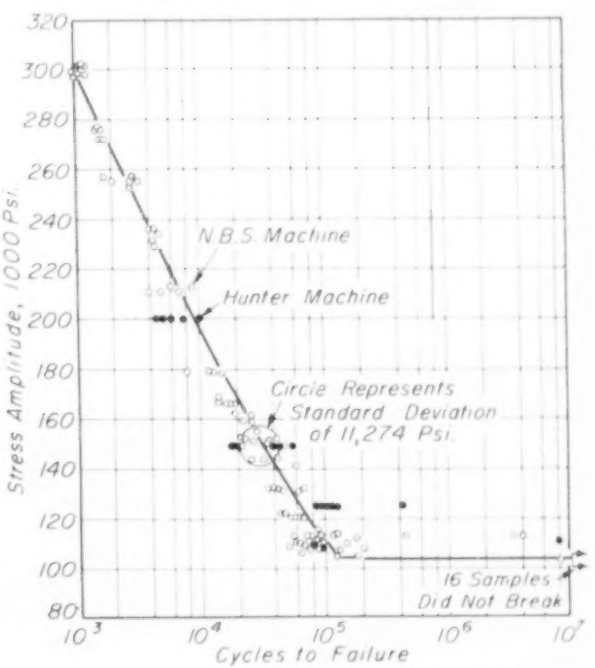


Fig. 2—N.B.S. Fatigue Testing Machine for Short Springs. Eight springs can be tested simultaneously in groups of four, at two stress levels

Fig. 3—Fatigue Tests on 0.039-in. HMA Music Wire Tested in Bending on the N.B.S. and Hunter Machines



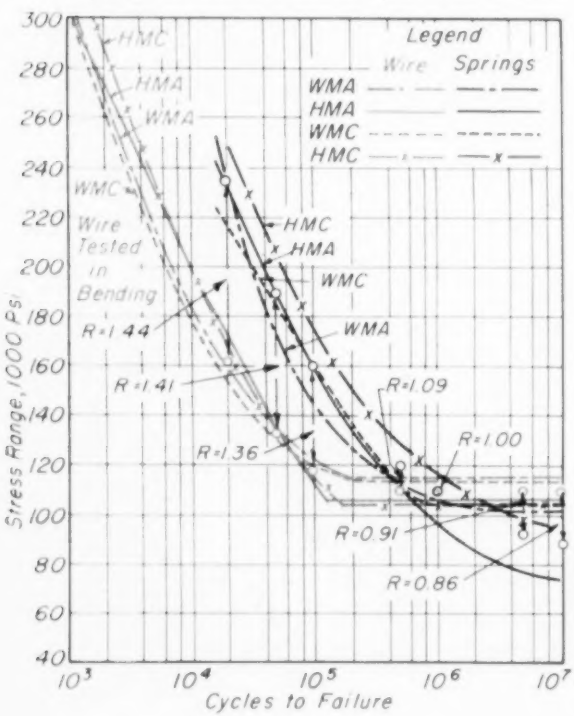
caused by the wire straightening operation. A number of specimens of the WMC 0.053-in. wire that had been straightened for reverse bending tests contained this type of defect. Their influence is reflected in the slightly larger coefficient of variation when comparing the WMC and HMC statistical data.

Figure 6 shows in color the S-N curves determined for each of the four wires. It will be noted that these curves fall within a range which is not much larger than the dispersion of data for HMA (Fig. 3 and Table I), admittedly the least uniform of the materials tested.

FATIGUE OF SPRINGS

Fatigue tests were also made in the machine shown in Fig. 2 on 24 short compression springs wound from each of the four coils of music wire. All were stress-relieved at 365° F. for 20 min. after coiling, and then pre-set ("scragged") by compressing enough to produce a stress in the wire of approximately 75% its tensile strength. See the black curves in Fig. 6.

Fig. 6–S-N Curves for Four Coils of Music Wire (in Color) and for Short Springs Wound From Them (in Black). Ratio of fatigue strengths, springs to wire, at various cycles are indicated



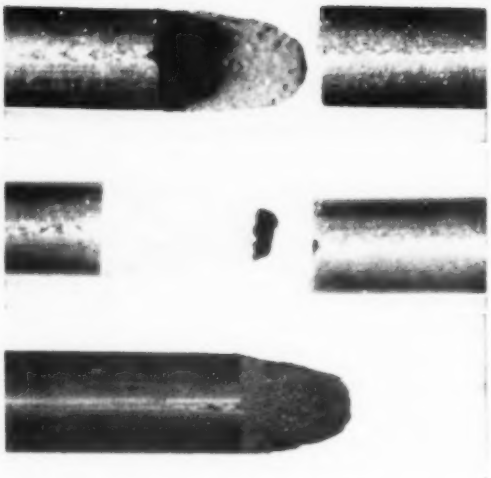


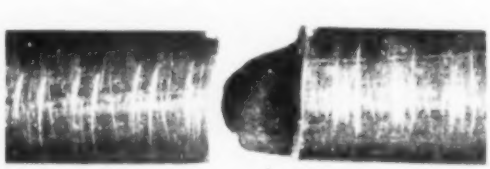
Fig. 4–Fractures of 0.039-In. HMA Wires Showing Surface Defects That Caused Failure During Reversed Bending Fatigue Tests. 15X

In these tests the mean stress was not constant, either from one spring to another or even during a single test, due to the unpredictable variation in set which occurred during the early part of the test. While this was undoubtedly a factor in increasing the scatter of results, it would not be expected to affect seriously the values of fatigue strength. No evidence was found of a correlation between mean stress and the deviation of individual results from the average.

An extra lot of 16 springs was made of type HMA wire and tested without stress-relieving. Lack of prior stress-relief did not appear to have any effect on the fatigue strength of these 16 springs.

The dispersion of the data was greatest in the springs wound from HMA 0.039-in. diameter wire. This increased scatter is directly related to the larger coefficient of variation found in the data of the reverse bending tests on this same wire, as shown in Table I, and is due to

Fig. 5–Fracture of 0.053-In. WMC Music Wire Stressed in Reverse Bending. Fracture occurred prematurely at surface scoring. 15X



the presence of longitudinal surface defects.

Examination of springs that had failed clearly showed that initial cracking always proceeded along a longitudinal plane of maximum shear stress. Cracks of this nature often extended for a considerable distance along the *inside* of a coil. Tensile fatigue cracks which later formed and progressed until complete fracture occurred always started at a short longitudinal shear crack, as shown in Fig. 7. A fatigue crack that had progressed three quarters of the way through the wire on the longitudinal shear planes is shown in Fig. 8. Abnormally large amounts of set and loss in spring constant during cycling may be attributed to the presence of such shear cracks.

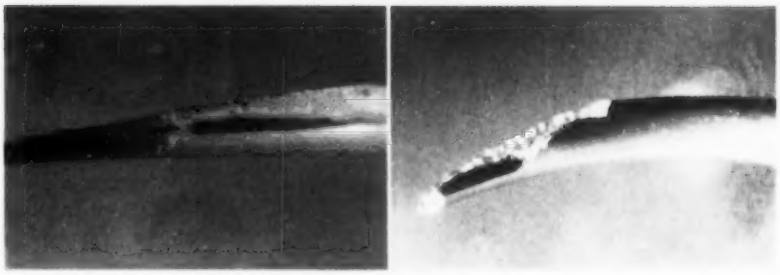


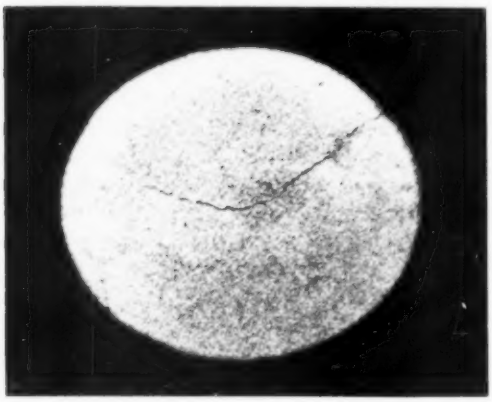
Fig. 7—Typical Fractures of Springs Wound from 0.039-In. Music Wire. 11.5X

These observations suggest that the maximum shear stress theory for failure is adequate in the case of springs.

CORRELATION OF WIRE TESTS TO SPRING TESTS

To compare the results of reversed bending tests on wire and the compression tests on helical springs, the ratio between the vertical ordinates of the two families of curves at various life was computed as follows: (These figures are also noted at the proper places in the curves of Fig. 6.)

Fig. 8—Cross Section of 0.039-In. HMA Wire From a Fractured Spring at a Point 0.25 In. From the Fracture. The fatigue crack has progressed three quarters through the wire on the longitudinal shear planes. The spring was tested at a stress range of 154,000 psi. 50X



Number of Cycles to Failure	Ratio, Strength of Spring / Strength of Wire
2×10^4	1.44
5×10^4	1.41
1×10^5	1.36
5×10^5	1.09
1×10^6	1.00
5×10^6	0.91
1×10^7	0.86

In assessing the significance of these ratios, consideration must be given to the differences in stress system and stress range. If we neglect the bending stress in the springs, the maximum shear stress is equal to the maximum tensile stress. For the wire bending tests, however, the maximum shear stress in the outer fiber is but half the maximum tensile stress.

There are also many factors which affect the relationship that exists between the two types of tests (for example, the directional properties of the wire and the difference in mean stress), but it is of interest to note that the ratio of unity which was found experimentally at 10^6 cycles would be expected in a homogeneous material if the only criterion of failure were the amplitude of the maximum shear stress in the outer fiber.

The agreement of the results from the four wires with the values listed above was sufficiently close to indicate that they provide a reasonably accurate method of estimating the fatigue properties of short springs from the reversed bending fatigue tests of the wire from which the springs are to be made.

We also conclude that reversed bending fatigue tests of wire will indicate the approximate fatigue strength of helical springs wound from that wire. However, the correlation is not sufficiently good to differentiate between samples of similar wire. Surface defects in the wire—even in this high-grade material given the best of attention in its manufacture—increased the dispersion of the data in tests on both the wire itself and on springs made therefrom.

Critical Points

by the Editor

In Praise of Old Friends

THIS ISSUE begins a new period in the life of *Metal Progress*. It is printed in Mt. Morris, Ill., by Kable Printing Co. For exactly 23 years since the first issue, September, 1930, this magazine has been printed by Tower Press in Cleveland. During that time it has received much praise and some medals for typographical excellence—deserved, we are immodest enough to think, yet received only because of the skillful craftsmanship of the compositors led by Ed G. Wilson and of the pressmen led by Charles J. Schleich. In all these years nothing was asked but what was cheerfully attempted by Herbert C. Hauser, manager of Tower Press, and his predecessor Charles J. Theuer. The change in printers was made primarily because *Metal Progress*, in its present size and circulation, has outgrown the economic capacity of Tower Press, essentially a "job shop" rather than a "magazine house." The old printing plant has established a high mark of excellence which the new printer can now shoot at!

ERNEST E. THUM

Ductile Iron for Hammer Castings

SHOULD you one day stop by Chambersburg Engineering Co. in the Cumberland Valley just south of historic Mason and Dixon's line and ask for Mr. Clarke, the guard will likely ask which Mr. Clarke you have in mind. He won't be kidding. Eugene C. Clarke is president and his three sons give him important administrative help. Eugene C. Clarke, Jr. is vice-president and works manager, M. G. Clarke is personnel manager and Samuel C. Clarke looks after the advertising. Under his guidance we toured the shops and foundry.

Chambersburg Engineering Co. has been building steam hammers and trimming presses of all descriptions for better than 55 years. Most of the forge shops in America have at least one of them—many of them veterans. Today, the airframe builders are operating another class of equipment called "Cecostamps"—Chambersburg's special design of drop hammers for shaping aluminum and magnesium sheet into aircraft fuselage elements.

The big noise at Chambersburg today, however, is the "Impacter", a really new type of horizontal forging machine in which dies are driven together from either side and strike the work suspended at the center. Some mysterious electronic controls operate the air valves so the moving dies with holders and propelling rams meet at the proper place with equal inertia, the opposing forces thus canceling out in plastically deforming the workpiece. The result is a forging machine without jar, and a speed of plastic deformation several times that hitherto thought possible.

Since the first of these impacters was completed, Air Force contractors and manufacturers of high-alloy turbine buckets for jet engines have installed units of various sizes. Meanwhile a research program at professional level has been initiated to throw more light on the novel metallurgical and mechanical aspects of the operation.

Large forging equipment requires unusually large castings, as everyone knows, and Chambersburg's gray iron foundry has become one of the country's largest melters of ductile or nodular iron. George Martin, assistant foundry superintendent, estimated that about 10% of his 750-ton monthly output is in this class of iron.

Cupola charges contain no return scrap, only premium pig iron and steel. Nodulizing (solidification with nodular graphite rather than flake graphite) is the result of additions of International Nickel Co.'s nickel-magnesium-silicon alloy during a reladling operation. Titanium in the pig must not run over 0.06% or trouble will be encountered. Tin and the omnipresent sulphur likewise interfere. Martin has experimented with additions of mischmetal—an alloy rich in cerium and the other rare earths, favored by Europeans as a nodulizing agent—to counteract the influence of excess titanium in the melt.

While the ideal is to produce the equivalent of malleable iron (or better) in the metal as cast, the massive castings made for cylinders, hammer frames or anvil blocks have tensile strengths on the order of 90,000 psi and elongation of 2.5%. (The latter figure can be boosted to 20% by subsequent heat treatment—at least in test bars.)

When large castings are being poured—and some of them run to nearly 150 tons—the cupola iron is augmented by the output of three oil-fired, bung-type air furnaces each of 55,000 lb.

capacity. They are charged with pig and cast iron scrap and will bring down a heat in about 10 to 12 hr.

A recent oversize casting was a 246,000-lb. base for a large steam hammer. It was cast in a pit, requiring 150,000 lb. of cupola metal, plus the iron from all three air furnaces. Its riser alone weighed six tons and had to be replenished with molten metal to take care of shrinkage for 24 hr. Cooling time for this behemoth was nearly a month.

All molds, as well as about 95% of all cores, are cement-bonded sand—a rather old idea, notable primarily because its advantages have not been more widely recognized and put to use. The mix is 180 lb. of portland cement to 1600 lb. of sand (40% reclaimed and 60% a washed silica sand of No. 50 A.F.S. fineness). To this is added 8 to 8.5% water. It has proved ideal for Chambersburg's foundry, since it can be rammed fast, sets very strong, and produces castings of greater accuracy than dry or green sand. However, since it sets quickly, patterns must be drawn as fast as possible; consequently, split patterns are used occasionally, as well as "drawbacks" or small cores set around a large pattern, which can be removed temporarily to free the pattern.

The foundry devotes about 80% of its capacity to the manufacture of castings to be used in forging hammers. Pours are made only twice weekly. The rest of Chambersburg's output includes a variety of large, intricate castings made for outside customers. A. H. A.

What Metals Will Throw a Spark

"NON-SPARKING" tools or equipment of hardened copper have acquired a good reputation in the minds of those responsible for safety in places where explosion hazards exist. Possibly because hard steel is so often the alternative material of construction, and hardened copper is relatively soft in comparison with steel, the impression may subconsciously exist that sparks are thrown off only from hard and comparatively brittle metal. It may therefore be surprising to know that sparks can be thrown from aluminum, magnesium or brass when struck against concrete or steel.

This is a curious matter, especially for such a soft metal as magnesium. Two recent occurrences, fortunately causing no great amount of damage, point up the case. Both involved cast magnesium "down pipes" used at gasoline loading racks or docks—tubes some 4 in. diameter, several feet long and about ¼ in. wall thickness. These are affixed to the end of the loading assembly at a "fill stand." In one instance one of these nozzles was dropped into an empty tank car, a spark was struck and ignited the gasoline fumes existing there. In another instance a workman had filled a tank trailer and shut the gasoline off, when the nozzle slipped from his hands, caromed off the side of the tank and landed on the concrete pavement. Some place enroute a spark was struck and a considerable gasoline fire resulted.

It may have been that these offending castings retained a small patch of magnesium sulphate and fine particles of magnesium, such as are frequently exuded on billets as described by Allen Russell in *Metal Progress* for February 1951. It seems rather doubtful that a little of this material had resisted the cleaning operation in the foundry. Another more likely possibility is that the spark came from a chromate film (known to produce a sparkable coating on magnesium) from the common pickling treatment used as a paint undercoat.

However, a coating is apparently not necessary. Frictional work can spark magnesium. For example, if a very fine cut is taken on magnesium with a dull tool, the chip may ignite, or if a good tool idles against the work at the end of a cut the fine particles torn off may burn. Sparks occur now and then when castings are ground or snagged with abrasive wheels, and an abrasive cut-off disk will throw a shower of dangerous sparks unless the work and tool are flooded with a coolant.

Thus it is not necessary for a metal to be *hard* to throw a spark. If the manner of impact is such that a small particle of soft metal is torn off and if the energy of impact is great enough to heat this particle to its ignition temperature in air, a spark will occur.

Corrosion—Do We Know Anything Much About it?

DURING AN INSPECTION of several A.E.C. installations made by the Atomic Energy Commission's Advisory Committee on Industrial Information, of which the Editor is a member, a truly impressive amount of experimentation and recorded data was observed on the corrosion of metals. Almost without exception,

however, the work has been done on an *ad hoc* basis. All the likely-looking commercial metals and alloys would be tested in the offending solution or molten mixture (under conditions as controlled as possible) and the sheep separated from the goats. Frequently, even the best of the sheep turned out to be a good deal of a goat!

Estimates have been made of the annual cost of corrosion to our metal-supported civilization. I don't remember the guesstimates but the sum was staggering. While the amount of money spent to discover ways of combatting it is also large—doubtless many millions a year—it must be a vanishingly small proportion of the loss it attempts to combat. Maybe it would be well to reappraise the whole matter.

What do we know about the fundamentals? Superficial answers can of course be given to such a question as "Why is copper or aluminum so much more resistant to atmospheric corrosion than iron?" or "Why is 18-8 subject to localized corrosion in salt water?" or "Why does titanium resist attack by hydrochloric acid?" But all too little is known about the real causes of the chemical reactions between the surface of a solid and a surrounding fluid. All too little is known about the *rates* of such reactions. Why does it sometimes occur rapidly and sometimes very slowly indeed? Sometimes we are reduced to the expedient of the ancients and fall back on the idea of a "noble" and a "base" metal. Until this ignorance is corrected we must rely on cut-and-try or a lucky guess to improve any bad situation.

It results that we are now paying a lot of money for our ignorance. It will cost a lot of money to get educated, but not nearly as much as to continue being dumb. Would it not be a good plan to collect a team of good metallurgists, physicists, chemists and corrosion engineers and turn them loose on the fundamentals of the corrosion problem? Since there are now two "centers" of research on corrosion—one at Cambridge, Mass., and one at Cambridge, England—maybe it would even be a better scheme to provide something like the Princeton Institute for Advanced Study, an atmosphere and an environment where some gifted scientists and some brilliant improvisors can quietly follow their inspirations—for in all likelihood it will take some lightning flashes to illuminate a field crisscrossed with well-worn paths of conventional test methods.

It won't be easy. To attain such a goal doubtless will take many years. But we'll never get there unless we start.

Intergranular Corrosion of High-Purity Aluminum

IT IS STATED by P. Lacombe and N. Yannaquis that the intercrystalline corrosion of 99.95% pure aluminum by hydrochloric acid reported by Rohrman in *Transactions* of the Electrochemical Society, Vol. 66, 1934, was not decreased by increasing the purity of the metal. For this reason they did not accept the hypothesis that the intergranular attack on the high-purity aluminum was due to the existence of impurities or constituents concentrated at the grain boundaries. They claimed that its origin must be attributed to the lack of registry at the boundaries between neighboring crystal lattices. This lattice misfit increases as the difference in orientation between the neighboring crystals increases.

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Corrosion tests carried out by the author on some high-purity aluminum in nearly neutral (pH 6.0 to 7.0) distilled water at 100 and 150° C. (212 and 300° F.) indicated that the intercrystalline attack is very similar to that in hydrochloric acid. The aluminum samples

shown in Fig. 1 were cut from a 0.030-in. sheet which had been rolled from a 2-in. slab machined from an aluminum ingot of 99.99% purity. (It contained 0.0045% Fe, 0.0017% Si and the copper content was nominally 0.002%.) The slab was preheated at 400 to 425° C. (750 to 840° F.) and then rolled to the required thickness without any intermediate annealings.

The sample at the left in Fig. 1,

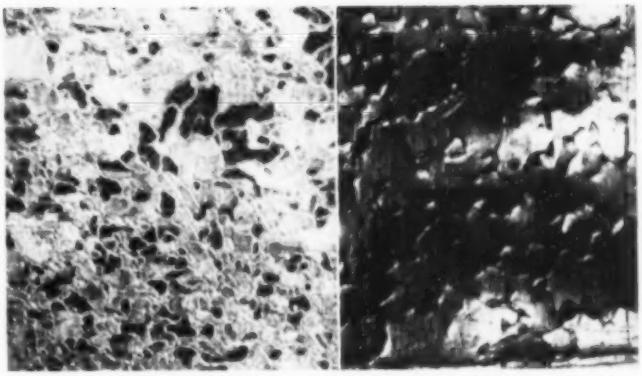
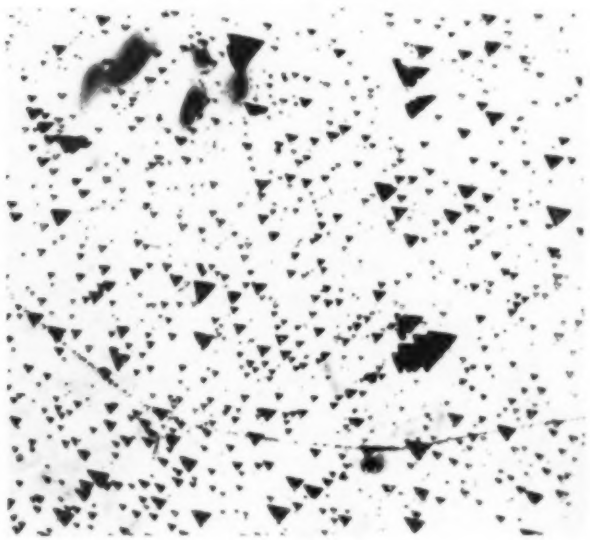


Fig. 1—(Left) High-Purity Aluminum Tested at 100° C. for 12 72-Hr. Periods. (Right) same material after testing at 150° C. for 12 days. 10X

Fig. 2—High-Purity Aluminum Tested at 150° C. for 12 days. Material was attacked intergranularly at misfit between adjacent lattices. 100X

Fig. 3—Material Same as in Fig. 2, but not Attacked at Grain Boundaries. 100X



after defilming in chromic-phosphoric acid solution according to A.S.T.M. specification B 137-45, was submitted to boiling distilled water of approximately pH 6.0 for 12 72-hr. periods. It was also defilmed after each period and the progress of corrosion determined. The illustration shows that the material was heavily attacked at the grain boundaries.

The micro at the right of Fig. 1 shows a sample of the same material which had been in distilled water of pH 6.1 in an autoclave at 150° C. for 12 days (after first defilming in the chromic-phosphoric acid solution). The intergranular corrosion was so severe that most of the grains were separated from their neighbors and some of them fell to the bottom of the autoclave. This material, as mentioned before, was not annealed after fabrication, but the rolling program was such that it recrystallized during its fabrication.

The sample tested at 150° C. was then defilmed and a specimen examined microscopically after electropolishing in fluoboric acid and etching with Tucker's reagent. Three grains are shown in Fig. 2; boundaries are severely attacked by the water, and etch-pits have developed on the surfaces of the crystals by the etching reagent. By means of these pits it is possible to determine approximately, and sometimes quite accurately, the orientation of the individual grains, and one can deduce that the bottom and top right-hand grains with triangular pits present the (111) faces, while the other grain shows the (100) face, which is characterized by quadratic etch-pit figures, sharply outlined at higher magnification. The difference in orientation

of the grains would indicate a high degree of misfit at the boundaries. Figure 3 represents three grains whose boundaries were not attacked in water. The etch-pits on their surfaces have the same form and approximately the same orientation.

Intergranular corrosion was also observed in some as-rolled Alcan high-purity aluminum (containing 0.002% Cu, 0.003% Fe and 0.001% Si) tested at 150° C. for 12 days in distilled water of pH 6.0. This material was produced and fabricated at Aluminium Laboratories, Ltd., Kingston, Ont., from a 2x4x6-in. ingot, hot rolled into a plate 0.250 in. thick after soaking for 3 hr. at 550° C. (1022° F.); the plate was subsequently cold rolled into a 0.030-in. sheet.

Figure 4 shows the structure of the material in the untested condition. Some recrystallization took place during the rolling, but in some regions a cold worked structure still prevails. The attack in water (Fig. 5) was concentrated mainly at the boundaries of the adjacent bands which became separated by intergranular corrosion. The distortion which occurred in the specimen during corrosion testing rendered the focusing for photomicrography quite difficult.

Other corrosion tests carried out by the author in distilled water at 150° C. on some high-purity aluminum indicated that sometimes the intergranular attack did not occur in unannealed metal, but always occurred when it was annealed. Analyses of the etch-pits on samples which resisted the attack revealed that the orientation of the crystals in the contiguous bands was very similar. The high corrosion rate for boiling distilled water on high-purity aluminum reported by J. M. Bryan (*Journal* of the Society of Chemical Industry, Vol. 69, June 1950) is probably due to the intergranular corrosion. His tests may have been too short in duration to observe its ocurrence.

Fig. 4—Banded Structure of High-Purity Aluminum, as Seen Before Testing. 250X

Fig. 5—Same Material After Testing Shows Attack Occurred Between Two Bands Which Have High Degree of Misfit Between Adjacent Lattices. 100X

Other experiments in water at 150° C. suggested that the high-purity aluminum with a 0.1% Si addition, annealed or unannealed, does not suffer intergranular attack. A metallographic examination of the tested samples showed no intergranular corrosion and a low degree of misfit between the adjacent lattices; this was revealed by the high directionality of the etch-pits, all of which show the (100) face in all of the grains. This material was not annealed but its fabrication was such that it recrystallized during the rolling operation.

SUMMARY

These results seem to indicate that metallurgical factors have great bearing on the corrosion resistance of high-purity aluminum, and when interpreting corrosion results its texture should be considered. The unpredictable behavior of the unannealed samples indicates that processing variables other than annealing are likely to have a marked influence on the corrosion resistance—for example, the poor corrosion resistance of annealed samples of high-purity aluminum, and the good corrosion resistance of all the samples of aluminum plus silicon.

For this reason, the corrosion resistance of both materials is being further investigated by us in its relationship to the influence of cold reduction and also the influence of cold reduction followed by complete annealing at various temperatures.

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Metal Finishing by High-Vacuum Metallization

FOR THE METAL parts manufacturer interested in surface decoration or coating with another metal, a new process has emerged which is destined to rank with electroplating in many common applications. This process, high-vacuum metallization, is concerned with applying to a metal (or other relatively nonporous base material) a coating which is abrasion resistant, nontarnishing and, where required, pleasing to the eye. It utilizes a discriminate combination of lacquer and a thin film of evaporated metal laid down under high vacuum.

Figure 1 is a sketch of the cross section of a typical coating resulting from this process. When appearance is relatively unimportant, the undercoat filler may be eliminated, and in certain rare applications where abrasion resistance and adhesion are not required, both lacquer coatings may be eliminated.

Since by far the greatest use of this plating method is in decorating or applying a reflective coating to such metal articles as die castings, stampings, slush castings, and machined pieces (see Fig. 2), we shall treat first with the details of the process when used on these pieces.

The complete high-vacuum metallizing process consists of three major steps. In sequence these are: *(a)* coating of the object with lacquer, and baking to provide a suitable base or undercoat upon which to evaporate the metal; *(b)* the evaporation of the metal in a high vacuum to produce the film; *(c)* coating with lacquer and baking to protect the thin metal film against abrasion or corrosion and general service abuse.

The first operation in vacuum metallizing is the application of the undercoat to the object to be metallized. This is necessitated by a number of factors.

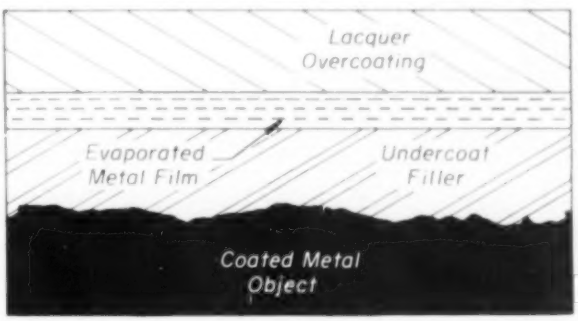
The microscopic pores of the surface have to be filled and sealed. The unsealed pores act as gas traps and cause interference by outgassing during the vacuum-coating procedure.

Surface irregularities, which would be optically exaggerated by the evaporated metallic film, have to be eliminated. The metallic thickness is of the order of a few millionths of an inch and would reproduce defects as well as good surface conditions. The undercoat smooths out the surface imperfections and gives the base the high gloss that is necessary for bright finishes. The possibility of galvanic action between the base metal and the coat of evaporated metal has to be eliminated. The undercoat provides the nonconductor necessary to insulate and prevent the corrosive combination.

Characteristics essential for a good undercoat are: adherence, low volatile content, correct composition and compatibility with topcoat. Thus, good adhesion is important because this largely determines the toughness of the film. Volatile constituents should be absent after the undercoat has been set because these will tend to migrate in relatively high concentrations to the surface of the film and cause difficulties in the vacuum metallization and in the adhesion of the topcoat. Composition of the undercoat determines the surface effects; these range from high gloss to wrinkle finishes. It is important that the undercoat have a composition which will adhere well to the topcoat and also not be soluble in the solvents used in the topcoat.

Good cleaning of all surfaces prior to undercoating is essential. Normal degreasing operations and thorough drying are usually sufficient. If tumbling abrasives must be used, adequate time must be allowed to insure that all pieces are thoroughly cleaned.

Fig. 1—Sketch of Vacuum-Deposited Coating



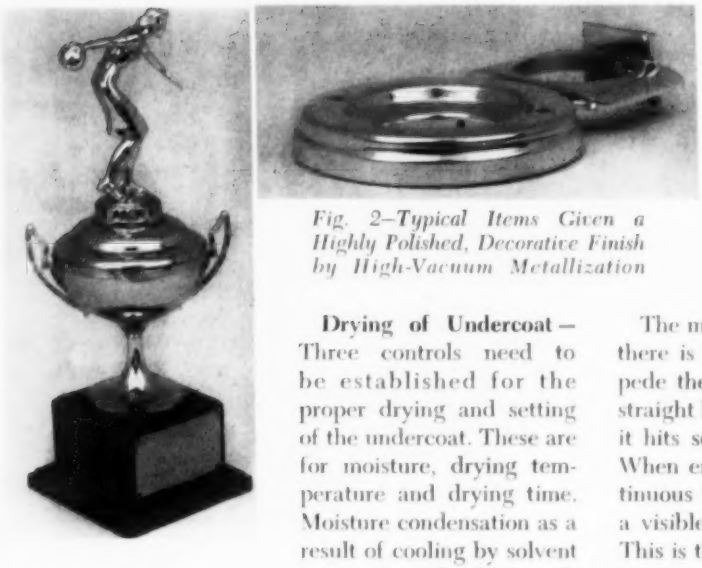


Fig. 2–Typical Items Given a Highly Polished, Decorative Finish by High-Vacuum Metallization

Drying of Undercoat – Three controls need to be established for the proper drying and setting of the undercoat. These are for moisture, drying temperature and drying time. Moisture condensation as a result of cooling by solvent evaporation should be offset by humidity control. The condensate (moisture) would affect surface characteristics, adhesion, residual volatility and compatibility with topcoat.

The second control establishes preliminary drying temperatures required for the undercoat to obtain good surface characteristics. High temperatures affect hardening and low temperatures affect setting of the composition. Finally, a minimum drying-time schedule must be established to insure completeness of volatile loss. A maximum drying-time schedule is needed to insure good adhesion between the bottom and top coats.

Application of the metal film involves basically an evaporation and condensation process wherein a metal, commonly aluminum, is brought to its boiling point inside a chamber which has been evacuated to 1/1,520,000th of atmospheric pressure.

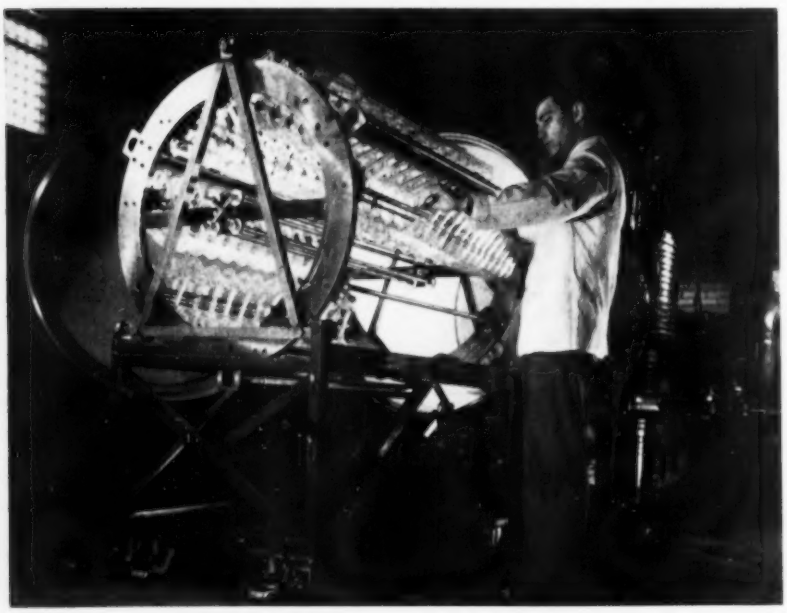
The metal boils off in a vapor form and since there is little air in the vacuum system to impede the movement of the vapor, it travels in straight lines from the point of evaporation until it hits some object on which it can condense. When enough vapor condenses to form a continuous film a few millionths of an inch thick, a visible metallic-appearing surface is formed. This is the metal coating provided by the process. It possesses all of the normal appearances of metal and has its electrical properties. These, of course, are the desirable characteristics obtained from the process.

Production equipment used for metallization is shown in Fig. 3. The vacuum is produced by a commercial high-vacuum system which employs in combination an eccentric cylinder-type oil-sealed mechanical vacuum pump, an oil diffusion pump, and a single oil-ejector pump.

The aluminum in the process is used to provide a bright, metal-like appearance and a surface that does not oxidize readily. Nothing is lacking in the way of physical strength or electrical conductivity. High purity of the metal is not essential, but purity contributes to the "color" of the film and may eliminate spattering due to sudden volatilization of impurities.

Although the coating metal is aluminum in at least 95% of applications, silver, gold, copper, zinc, chromium, cobalt, nickel, selenium and many metallic compounds and alloys can be deposited. Preference for aluminum is because of its low cost, high reflectivity, and resistance to tarnishing. In addition, it can be deposited without difficulty and its covering

Fig. 3–Holding Fixtures Being Loaded With Parts for Metallizing; Unit Slides Into Tank Chamber Directly Behind



properties are such that 1 lb. of aluminum will coat 25,000 sq. ft. of surface.

The metal is evaporated from coiled tungsten filaments so laid out that all surfaces of all objects to be coated are exposed to at least one filament. The metal to be deposited, in the form of small wire stirrups which are hung from the filaments as shown in Fig. 4, is brought to its boiling point by passing electric current directly through the filaments. Aluminum, the most widely used evaporating metal, has the property of wetting tungsten when in contact with it under high vacuum and in a molten state. Thus it spreads over the filament surface providing a relatively large area from which vapor emanates. Customarily, the current to the filaments is controlled by means of a variable transformer. In a production system, the thickness of the metal film is determined by timing the duration of the evaporation as well as by measuring the amount of current through the filaments.

Fig. 4–Size of Stirrups of Coating Metal Used on Tungsten Filament Which Is Also Shown

It is essential that the pressure in the evaporating chamber be measured so as to insure a metallic coating of high quality. A pressure of one micron or lower is considered mandatory; otherwise, dark oxidized surfaces are likely to result. Most systems, therefore, are provided with vacuum gages such as the Pirani or thermocouple-type, which operate on the thermal conductivity principle in the range of one millimeter of mercury to one micron, and the ionization-type for use from one micron to 1×10^{-6} mm. of mercury. The latter type is based on a sensitive element in which a hot filament or a high voltage ionizes the residual air in the element. A grid and plate accelerate and pick up the positive ions respectively, and measure them quantitatively on a meter. This measurement is proportional to the pressure in the system.

After metallizing, the object is given a colorless organic coating to protect the metal deposit against general service abuse and also to provide the medium for introducing color effects. The compositional characteristics required of the undercoating are applicable to the topcoat; in addition it must meet all anticipated service abuse, such as abrasion, humidity, solvent attack, impact and exposure to ultra-violet light. Also, the topcoat should be compatible for dye-tinting procedures. The usual metal deposit, aluminum, is reflective for the entire visible spectrum; consequently, dye-tinting creates a range of metallic appearances varying from all tones of gold through copper, and including virtually all colors of the spectrum. The lacquers have good resistance to abrasion while color fastness of the dyes lasts from one to two years in sunlight and is perfect for indoor use.

In the previous discussion of undercoat composition characteristics, note was made of the relationship of residual volatility to subsequent out-gassing in the vacuum chamber. Since the topcoat is not exposed to a high vacuum, this no longer is important. However, it is essential that aging does not affect the undercoat and distort the metal film.

While the decorative metal-on-metal application appears to have the largest present potential usage, there are others which should be mentioned in any discussion of high-vacuum metallization of metals. For a number of years, selenium has been evaporated on metal plates which are subsequently ganged to form simple electric current rectifiers. In this application, the selenium deposits on the plate in a uniform fashion, normally adheres well and does not require a protective coating. The vacuum process is cleaner and can be done less expensively than other competitive processes.

Selenium is also deposited under high vacuum to produce the sensitive elements used in photosensitive instruments, such as light meters. Its particular capability for receiving and holding electrical charges, plus its photoconductive properties, has made it particularly useful in the new photo-copying process, Xerography. In this process, the sensitive plates are prepared by evaporation of a thin film of selenium under high vacuum onto metal plates.

For many years, metal reflectors for automobile headlamps and flashlights have been prepared by using a thin film of aluminum or silver evaporated under high vacuum onto a highly reflective surface of an enamel-coated metal. The metal backing is usually a steel or brass stamping. A high-temperature baking enamel is either sprayed onto metal and rotated to obtain a perfectly smooth surface, or the entire piece is dipped into the lacquer and withdrawn at such a rate and at such an angle as to

Vacuum Metallizing

produce the ultimate in smoothness of coat. In most instances, no protective overcoat of lacquer is applied since this would tend to reduce the reflectivity of the metallized surface.

In summary, it can be said that high-vacuum evaporation of metals onto other metals has reached a position of economic and practical utility where decorative considerations are primary. The process has also matured for several uses of selenium metal.

Other products are now in the service-test stage and appear to be working out satisfactorily. Each of the many methods of depositing metallic coatings has its specific advantages. In vacuum metallizing these are: low production cost (compared with electroplating and silver coating), fast operation because it will handle large number of units in batches or continuously, and high production output. However, although the process has many applications where its economy and other advantages are established, the process and equipment are still in the early formative years and therefore experience is limited and not highly systematized. Also, despite its simplicity of principle and equally simple operation, proper installation of equipment and its application requires experienced engineering advice.

The future of the process lies strictly in the hands of the metallurgist who is looking for a new way, or simply for a way to combine metals to produce a particular result not yet attainable. We hope this presentation will promote the use of many unusual combinations of dissimilar metals through the medium of high-vacuum evaporation.

Book Review

For the Patriotic Metallurgist

BY GLEN C. RIEGEL*

BORON STEELS: *2nd Revised Edition. Ernest E. Thum, Editor. American Society for Metals, Cleveland. 112 p., paper cover, 9x12 in.* $1.00

YOUR HEARTBEAT quickens, and you swell with pride as the "Stars and Stripes" leads the military band parading down Main Street. Patriotism prompts head and hand as you doff your hat. You are a loyal American.

Editor Thum makes it plain that patriotism and loyalty to our American way of life must run deeper than our up-welling emotion. We do not have, in our wonderful land, all the alloy needed to produce the simplest steel, much less the rich alloy steels.

How could we exist if we were a nation isolated from our present sources of imported raw materials? How could we wage a war of defense if we were deprived of the alloys required by the military and almost entirely denied in wartime to the civilian?

When should we practice getting along with little or no alloy? When the emergency arises, or while we still have time to prove that we can do without?

In this reviewer's opinion, we had better read every useful experience in this bulletin on "Boron Steel", so frankly told by the leading engineers who get the most out of their steels. *Now* is the appointed day to prove that you can build a truck or tractor transmission without nickel, chromium or molybdenum.

A mighty airwing defense can preserve your factory intact, but the airwing needs all the alloy specified. The automobile, the truck, the farm tractor, the garage tools, this booklet shows, need very little alloy that boron cannot supply. In fact, many of our earth-borne vehicles could be built without using any alloy steel, except in engine valves and a few other small accessories. Piston pins, connecting rod bolts, transmission gears, bevel and drive gears have all been made satisfactorily out of plain carbon steel. By using boron as an alloying element, even the heat treatment doesn't have to be changed from oil quenching to something more drastic.

If you are a director of engineering, a designing engineer, a purchasing engineer, and most particularly a metallurgical engineer and have not read and understood the implications of this pamphlet, your economic education has been neglected—and your patriotism imperiled.

What's more, you can save money in this uneasy peace and at the same time, strip your product down to fighting weight. That is what these steel-using experts are doing their best to tell you in this booklet.

* Glen C. Riegel is chief metallurgist for Caterpillar Tractor Co., Peoria, Ill.

Units for Measuring Variations in Measurements

ENGINEERS are accustomed to devise suitable measuring units to express the magnitude of the physical properties of engineering materials—pounds per square inch, for example. Such units are so familiar that they are usually taken for granted, especially when the unit can be visualized and found to be meaningful.

Other units or scales have arbitrary bases. Mohs' scale of scratch hardness for minerals is such a one, wherein values 1 to 10 are assigned to ten materials ranging from talc to diamond. Other hardness scales are available for metals, such as the diameter of the indentation made by a hardened steel ball under 3000-kg. load.

Both these scales of hardness have a recognizable meaning in terms of everyday experience with the common concept of hardness. Sometimes the connection between unit and utility is more remote. Thus it is difficult to see any simple property that is measured by the Charpy notched-bar test, yet such measurements are considered, at least by some engineers, to furnish information on certain performance characteristics of metal.

Making measurements of one kind or another is a primary activity for most inspectors, experimental scientists and many engineers. Judgments are then formed by appraising these magnitudes against the individual's accumulated experience with such measurements. Often they are directly compared with some specification to determine the fate of the material in question.

Men have learned also by experience that measurements vary, and that the fate of borderline material may depend on this variation. On one test the material may fall just short of specification; on a repeat test the inherent variation in the measuring process may turn up a result which meets the specification. The material has not changed; the uncertainty lies in the limitations of the procedure for making the measurement, or in the sample selected, or possibly in both.

In the early stages of the development of a craft, attention is properly directed to refining the techniques of measurement. Attempts are made to reduce the variation shown by repeated measurements on the same material to such a low amount that it can be neglected. When this is achieved there is no uncertainty about whether or not a product meets specification—and inferentially about the performance of the product.

This happy state of affairs is not easy to attain. Sometimes, by building extra quality into the product, one can be sure that *all* measurements meet specifications and there will be no rejections. This can be expensive. On the other hand, whenever we crowd the specification we risk the chance that good material will be rejected, not because it is defective but because the measurements vary.

It is at this point that someone begins to look into the subject of statistics, since it is rumored that statisticians can get information out of data. It will be my concern to give the reader some indication of what it is the statistician has to offer. The somewhat lengthy introductory remarks on units had a purpose. We shall need a *unit* to measure variation. Three are commonly used.

UNITS TO MEASURE VARIATION

Range of Observations—Even if but two measurements are available, the difference between them is a measure of the variation shown by such masurements. For example, two pieces were clipped from a coil of steel wire and tested in tension; one result gave 86,400 psi., the

By W. J. YOUDEN
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Computing the Standard Deviation

other 88,800. The difference between tests (variation) is 2200 psi., and the arithmetical average is 87,600 psi. It requires considerable experience with such material and such a test to pass judgment on the agreement shown by this pair of readings and determine whether or not to place confidence in the average value.

If more than two readings are available a simple extension of the rule of taking differences leads to using the *range*—that is, the difference between the largest and smallest measurements in the set—as a measure of the variation. The third test on the above coil gave the experimenter 85,400 psi. The inspector now has three values for what is supposedly the same thing, namely 85,400, 86,400 and 88,800. The difference between high and low is 3400 psi., and the arithmetical mean is 86,900 psi. Obviously the difference, high to low, is a simple unit to express variation, but its real meaning also depends upon the number of measurements in the set.

The mathematicians tell us that five measurements will, on the average, have a range more than twice as large as the average difference between two measurements. Also that the average difference between the largest and smallest of a group of 14 measurements exceeds three times the average difference between a single pair of measurements. Now, the intrinsic variation of the measurement operation is the same, regardless of the number of measurements taken, so any unit for measuring variation, such as the range, that depends upon the *number* in the group must be adjusted by an appropriate factor.

Average Deviation—Another unit for measuring variation is the "average deviation"—simply the average of all the differences (without regard to sign) obtained by subtracting the average for the group from every measurement. This unit is in widespread use by engineers and scientists. I imagine it would not be used so much if the user knew that this unit, like the "range," depends upon the *number* of measurements in the group. Indeed, the average deviation, if groups of three measurements are taken, is, in the long run, only 0.85 of the theoretically correct value for the variation, and this correction factor depends on the number of observations in the group. Almost invariably this correction to the unit for measuring variation is ignored, yet no engineer would use a unit of length, say, that got larger for long objects than for short ones!★

Standard Deviation—Statisticians have their favorite unit for measuring variation among measurements. It is called the "standard deviation" and is computed by squaring the differences from the average deviation and dividing the sum of the squares by one less than the number of measurements. The final step of taking the square root of this quotient returns the unit to the same scale as the original measurements. The value of the deviation so calculated is designated by σ; it is really an *estimate* of the true, but unknown, standard deviation designated by σ'.

This arithmetical manipulation seems like a tedious process—but so is the process of taking the measurements in the first place!

The square of this unit meets the first requirement that, on the average, its calculated size is not influenced by the number of measurements used in its computation. Equally important, this unit is particularly well adapted to answering the questions that experimenters are bound to ask about their data. The required numerical operations are simple and may be performed by inexpensive computing machines. Furthermore, the standard deviation extracts more information from the data than the "range" or the "average deviation."

(A word of caution may be interjected at this mentioned immediately, although it will be implicit in much of the later discussion, and that has to do with the number of measurements which should be made. The use of sets of three is a time-honored custom. Only lately have we asked ourselves whether it was worth the trouble to do a little better—whether anything valuable could be gained by going to four or five. The answer is "Yes". You get a lot more, really a *lot* more, for a little more work. Your judgments are a good deal sharpened. This is, I think, one of the valuable byproducts of statistical analysis.

★Take the data on wire strength already quoted, as shown in the adjacent column.

When two more observations were made, they turned out to be 88,700 and 91,200. The data for this group of five are also shown.

The average engineer would probably hold that the average of five tests (87,900 psi.) is a closer approximation to the "true" strength of the wire than the average of three, yet the average deviation of five tests would appear to indicate that it has a higher degree of uncertainty.

Another consideration might be

Data for Three Observations

Observation		Deviation
85,400		1500
86,400		500
88,800		1900
Mean 86,900	Av. dev.	1300

Data for Five Observations

Observation		Deviation
85,400		2500
86,400		1500
88,700		800
88,800		900
91,200		3300
Mean 87,900	Av. dev.	1800

point. We are here considering measurements which are independent and of equal precision. If the measurements are not independent, the information furnished by one measurement is, in part, a duplication of information already supplied by other measurements, so this reduces the effective size of the set of measurements. Furthermore, if measurements have varying precision, it becomes necessary to weight them appropriately; otherwise a single imprecise reading may dominate the others.)

WHAT WILL THE DATA SHOW?

Suppose we enumerate some of the questions that experimenters ask about data and give some elementary examples to show how the standard deviation is put to work to answer them. They will show that a unit for measuring variation is indispensable for a really close examination of a set of measurements.

Is the Domain Less Variable?—In the first place it is often desirable to be able to state the variability of a measurement procedure. Take the five measurements in the first column below. They average 2.33. The second column lists values of the deviation x, the difference between each measurement and the average, while the third column shows x^2, with Σx^2, the sum of the squares, at the bottom.

Measurements	x	x^2
2.39	0.06	0.0036
2.31	−0.02	0.0004
2.38	0.05	0.0025
2.32	−0.01	0.0001
2.27	−0.06	0.0036
Av. 2.33		$\Sigma x^2 = 0.0102$

Now the standard deviation σ is computed from the formula

$$\sigma = \sqrt{\frac{\Sigma x^2}{n-1}}$$

where n is the number of measurements. Here

$$\sigma = \sqrt{\frac{0.0102}{5-1}} = \sqrt{0.0025} = 0.05$$

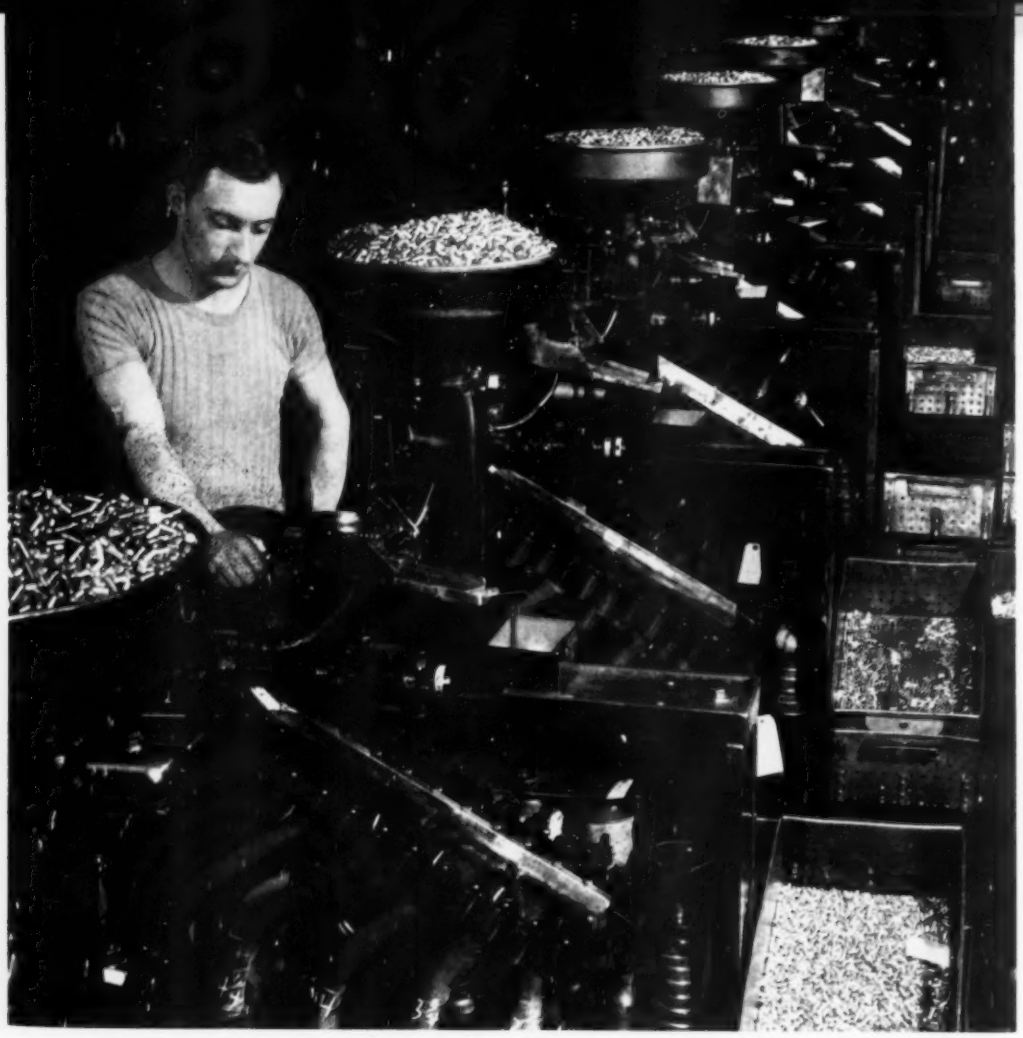
The result, 0.05, is called an *estimate* of the standard deviation because, obviously enough, another set of five similar measurements of the same thing will lead to another result differing somewhat from the first. The original readings (more truly called "estimates" of the property) show a variation; consequently we may anticipate some variation among a series of estimates of the variation.

Further questions immediately come to mind. Suppose these measurements have been obtained by a modification of a test procedure which long experience has shown to have a standard deviation of 0.12. Are the above data sufficient to warrant the conclusion that a real improvement has been achieved in the test procedure?

To answer this question the statistician will divide the sum of squares, 0.0102, from the five results, recently acquired and listed above, by the square of 0.12 (the previously accepted standard deviation) obtaining $0.0102 \div 0.0144$ or 0.71. This ratio, known at x^2 (chi square) is looked up in a statistical table (see I in the Data Sheet, p. 96-B) which informs the statistician that only once in 20 times would he get five measurements to agree as well as these do, *if* the procedure has not been improved and therefore still had the original standard deviation of 0.12. Perhaps this is the lucky one-in-twenty shot! The usual conclusion, however, is that a real improvement has actually been effected.

How Many Measurements Are Needed?—There is another question we might consider even before the measurements are taken: We may set our sights a bit lower and decide, in advance, that we would be pleased if a certain modification in our manufacturing method would cut the actual standard deviation in the product or process ("domain" is the technical

Last year the energetic Philadelphia Chapter of the American Society for Metals arranged for a series of four educational lectures on "Practical Applications of Statistics in Laboratory and Production." Attendance was gratifyingly large and interest was sustained to the end. A poll was taken of a random sample of *Metal Progress* readers (selected, it should go without saying, with due regard to statistics) and 71% expressed their desire to see this material in print—a result which might have been deduced directly from the attendance records in Philadelphia. This first paper on statistical units of measurement will be followed by others on analysis of test data, quality control by Aluminum Co. of America, and quality control in steelmaking.



Sorting Rolls for Size on a Timken-Designed Gaging Machine in the Canton Bearing Factory of the Timken Roller Bearing Co.

term for the phenomena being measured) to one-half the former figure of 0.12. If the modification has really brought about this much improvement we would like very much to establish that fact.

It is necessary to face the possibility that, in any given group of measurements, the estimate of the standard deviation may, by chance, be low and we could be misled. We shall insist, therefore, that the estimate obtained from the new measurements be *below* such chance values. Otherwise we will not be impressed. On the other hand, the modification to be appraised may really be such that it is cutting the standard deviation down to one-half its former value; nevertheless the set of measurements obtained gives, by chance, an estimate somewhat *above* the real value σ'.

How many measurements, then, should be taken to prevent us from concluding that an improvement has been achieved when in fact it has not, and also give us a good likelihood of catching this improvement if it really has been achieved? Tables have been prepared to guide the experimenter in this matter. If he wants to risk only one chance in twenty of believing in an improvement when none has taken place, and to have nine chances in ten of picking it up if this 50% reduction has actually been achieved, such tables show that 12 measurements should be collected. If this seems a large number, it means that some people underestimate the amount of work that it takes to demonstrate that such an improvement has been made. A short table is given at H in the Data Sheet, p. 96-B.

Maintaining an Improvement—These techniques for assessing the variation among measurements are, of course, equally applicable to the assessment of the variation shown by units of a product which is being manufactured. Almost always the objective is to achieve greater uniformity, and various steps are taken with this in mind. Sooner or later the question

arises: "Has the variation been reduced by the steps taken?" It may be that there is no limit on the number of units (and measurements) available to the statistical analyst. On the other hand, if each test destroys a valuable item, or if the measurement of quality or performance of the product is expensive (as a block test of an airplane engine), then it is useful to be able to make an estimate, in advance, of the amount of work required to arrive at a sound decision. Not the least benefit accruing from the statistical approach is that it removes the matter from the field of personal opinion.

Variability Between Two Suppliers—Another variation of this question is often encountered when a purchaser may be offered the same item from two suppliers. Naturally he will wish to choose the more uniform, the one showing least variation; presumably this will assist him in producing a uniform product.

Here the variability of neither material is known in advance. The purchaser must first estimate the standard deviations for products from both suppliers. These are compared by taking the ratio of the squares of the standard deviations, setting up the fraction so that the ratio is greater than unity.

Suppose the estimate of standard deviation from 20 samples from supplier A is 0.065 and from the same number from supplier B is 0.092. The ratio of squares is

$$\frac{0.092^2}{0.065^2} = \frac{0.008464}{0.004225} = 2.01$$

This ratio is called F, and it must attain a certain critical value before it can be concluded that a difference in variability between the products really exists. A brief table is given at III in the Data Sheet (p. 96-B), from which it may be concluded that there is only one chance in ten that the material from the two sources actually will be found on further testing to have approximately the same deviation, rather than being different breeds of cats, so to speak.*

Furthermore, statistical tables are available to guide the purchaser in the amount of data required to be reasonably sure of detecting a difference in variability that would be important in his process. (See IV, p. 96-B.)

HOW MUCH CAN AN AVERAGE VARY?

The above examples by no means exhaust the list of ways of making good use of information about the variation exhibited by a group of numerical quantities. This variation is one of the reasons for making repeat tests, for it is well known that the average of a series is less prone to variation than the individual measurements entering into that average. In fact, the standard deviation of the average of n measurements is estimated by dividing the calculated standard deviation by the square root of the value of n.

This is one step toward answering a question of greater interest to the man with the data. He would like to know whether an interval can be specified such that, when centered on the observed average, he can have a certain confidence that it will bracket an average based upon a great many more measurements. If, then, this interval does not overlap some rejection value, the data do not contradict the claim that the product meets the specification. (Of course, there is a chance—and this can be made a long chance.)

Here again there are two distinct situations—first, the case where the standard deviation has been established through an accumulation of earlier records and, second, the case in which the limited set under examination is the sole source of information on the variation of the data. It is reasonable to expect that a narrower interval can be set if a well-established figure is available for the standard deviation. Indeed, for 95% confidence it is customary to make the interval extend 1.96 times the standard deviations† on either side of the average. This spread or factor t becomes larger the smaller the number of measurements available for estimating the standard deviation. With an exceedingly large number of measurements the factor is 1.96, with 20 measurements it is 2.09, for 10

*In the discussion at the Philadelphia meeting, Dr. Youden was asked to elaborate on "this strange F value" and he said:

"F is simply the ratio of two squared standard deviations. Its behavior can be described mathematically. If you know what can happen to the value of F *when both sets of measurements come from the same source* you're in a strong position, because if you have two sets of data and you get a value of F that's outside the tabled limits, then you feel pretty sure these two sets of data did not come from the same source.

"This is the line of reasoning which is characteristic of all statistical processes. We set up what is called, technically, the null hypothesis—that is, we go on the assumption that there is no difference between two sets of measurements. Some statistic, such as F, is then calculated, and if its value lies outside the range of values that may reasonably occur when the two sets of data arise from a single population or domain, we perforce reject the null hypothesis. We would then have strong evidence that the two sets of data refer to different systems."

†Standard deviation of the *average*.

What Does It Cost?

measurements 2.26, and for 5 measurements 2.78. (See V in the Data Sheet, p. 96-B, which lists a few t values taken from published tables.) The larger factors for smaller domains reflect the additional uncertainty introduced by the variation in the estimates of the standard deviation, which naturally enough gets worse as the number of measurements becomes smaller.

When earlier records provide a reliable estimate of the standard deviation, one can specify the number of measurements required to have a given chance of picking up a shift in the average. The shift is expressed in units of the standard deviation. Clearly, a shift that is large in terms of σ' would be easy to detect, but one that is only a fraction of σ' would require more measurements. A table such as VI, p. 96-B, may be consulted for the required number of measurements. The table vividly shows the large number of them before one can be reasonably sure of catching a small shift in the average. Thus, 42 measurements are needed to be 90% sure of finding out that the quality has actually shifted by an amount equal to half the standard deviation.

During 24 years at Boyce Thompson Institute for the study of plant biology and pathology in Yonkers, N.Y., Dr. Youden became well known for several developments in the field of chemical equipment and for the invention of a group of experimental designs now known as "Youden Squares". He received the Medal of Freedom for his contribution to the improvement of bombing accuracy during World War II. Since 1948, he has been with the National Bureau of Standards in Washington as a statistical consultant to the scientific staff, also serving for three months in 1950 in a similar capacity at the National Physical Laboratory in England.

MUCH COSTLY DATA ARE UNNECESSARY

There are still some who imagine that statistical procedures can only be used when large masses of data are involved. This simply is not true. Often these same people do not hesitate to express their intuitive judgments upon rather small sets of data. But statistical procedures are nothing more than the translation of such intuitive judgments into more exact appraisals by using an appropriate unit for measuring the variation in the observed results.

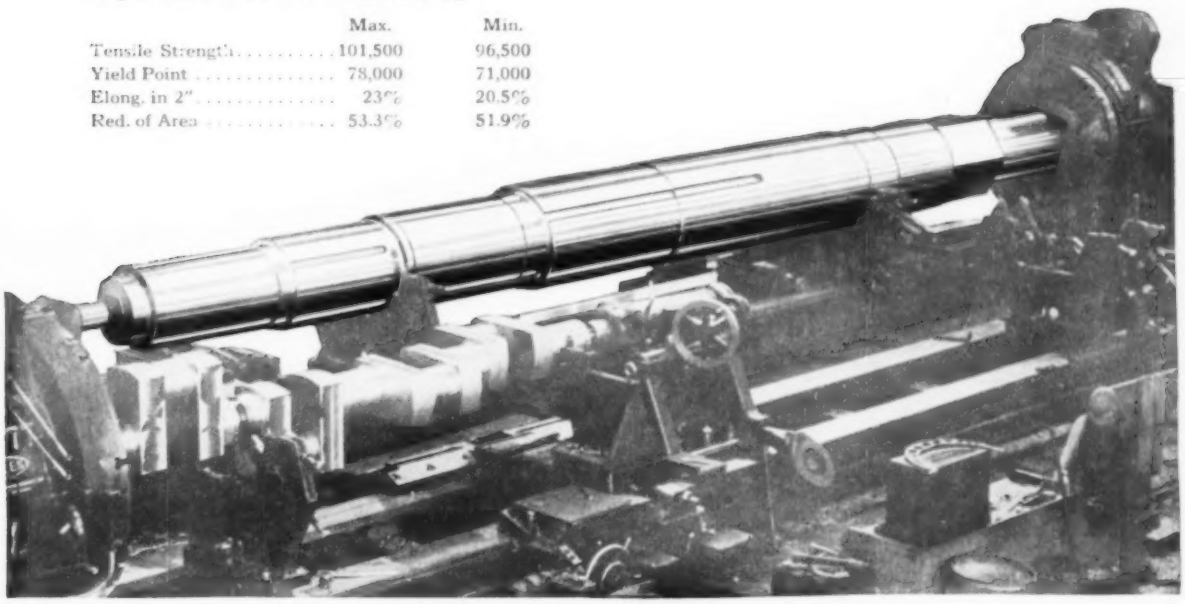
Ever since men began to make measurements they have focused their attention on the quantity under measurement. There is always a second quantity which requires measurement. This second quantity is the variation in the original measurements—the scatter they exhibit about their average. The examples given above show emphatically that it is desirable to have a unit to measure this variation. Once this variation has been measured it is relatively easy to face questions about the data which sooner or later will confront every experimenter or executive interested in improving quality and uniformity of a manufactured product.

Finally the matter of costs erects its ugly head. It has been asked, "If we add to the straight-forward appraisal of data in which we ignore all questions of costs and introduce the dollar sign, can we then set up tables or methods to guide us?"

The answer is yes. Some of the formulas now exist; others are in process of being applied to the more complicated cases. The cost of taking a sample is $X and the cost of analyzing or making one measurement on a sample is $Y. The division of one's expendable dollars between the number of samples and the number of analyses per sample can be determined by considering the standard deviation and the cost involved in both these steps. This formula is in the books and it is only a matter of putting it to work. Much statistical work has been quite arbitrarily planned and I am sure that many of the operations required by present specifications will be examined in the years to come with a sharp eye on the dollar cost. However, we must solve the simple problems first without regard to the dollar before we move in and put in the dollar sign as still another variable term in the formulas.

NICKEL STEEL FORGING . . . a 58,950 lb. hoist drum shaft, 24" in diameter at its widest portion and 42' 9" long, produced by ERIE FORGE & STEEL CORP. Inspection revealed very fine grain. After being normalized and drawn, actual tensile tests in the longitudinal direction showed the following:

	Max.	Min.
Tensile Strength	101,500	96,500
Yield Point	78,000	71,000
Elong. in 2"	23%	20.5%
Red. of Area	53.3%	51.9%



How Erie Forge Obtains

Superior Properties in Large Forgings

To develop high tensile and elastic properties in large forgings, such as this giant shaft, by heat treatment is much more difficult than with smaller forgings.

For even though dimensions of a large piece may allow liquid quenching, section sizes involved ordinarily limit the cooling rates.

Experience shows that superior mechanical properties in large forgings depend largely on suitable alloy content . . .

Fundamentally, that is why the output of ERIE FORGE & STEEL CORPORATION of Erie, Pennsylvania, includes scores of large forgings produced from nickel alloyed steel.

Nickel, either alone or in combination with other alloying elements, exerts highly beneficial influences. Its strengthening effect on ferrite is independent of carbon content or heat treatment of the steel, while its effectiveness in reducing the rate and temperature of the upper transformation, induces better response to the necessarily milder heat treatments used.

Nickel alloy steels may help you obtain peak performance from vital parts of *your* products or equipment. Send us the details of your problems for our suggestions. Write us now.

At the present time, nickel is available for end uses in defense and defense supporting industries. The remainder of the supply is available for some civilian applications and governmental stockpiling.

INCO

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N. Y.

Statistician's Tables for Appraising Variability

For significance and use, see "Units for Measuring Variations in Measurements", by W. J. Youden, p. 91.

I

Critical Values for Chi Square (χ^2)
1-in-20 level; n measurements

n	Lower	Upper
2	0.00393	3.841
3	0.103	5.991
4	0.352	7.815
5	0.711	9.488
10	3.325	16.919
15	6.571	23.685
20	10.117	30.144

This table is used to determine whether a group of n measurements shows less variation than some accepted value of the standard variation σ', or more variation. One in 20 sets of measurements will yield values below the lower critical values shown in the table, and one will yield values above the upper critical values, even if the system actually has the same standard deviation σ' as before, and which is squared in the denominator of the formula for $\chi^2 = \frac{\Sigma x^2}{\sigma' \cdot \sigma'}$. Larger tables are available in most statistical texts wherein the entries will be found opposite $(n - 1)$.

II

Number of Measurements Required to Reveal Whether a Given Procedure Has a Standard Deviation That Is a Given Fraction of an Assigned Value

Given Fraction of Assigned Value	Chance That Indicated Number of Measurements Will Reveal Improvement	
	4 Out of 5	9 Out of 10
0.70	28	33
0.65	20	26
0.60	15	19
0.55	12	14
0.50	9	12
0.45	8	9
0.40	7	8

χ^2 for the set of measurements, when they are obtained, is calculated as in I above, and is judged by the lower critical values listed in I. The numbers of measurements that are entered in II are sufficient to reduce the chance of claiming an improvement, when in reality there has been no improvement, to 1 in 20. The second and third columns refer to the chance of detecting the improvement, if it actually exists, to the extent indicated in the first column.

For larger tables see "Selected Techniques of Statistical Analysis", edited by Eisenhart, Hastay and Wallis, McGraw-Hill Book Co., Inc., 1947.

III

Critical Values for the F Ratio $\left(F = \frac{\sigma_1^2}{\sigma_2^2}\right)$

(Each group with n measurements)

n	F
2	161
3	19
4	9.28
5	6.39
10	3.18
15	2.48
20	2.13
25	1.98

Data for n and F apply to the circumstance that there is one chance in ten of attaining F if both sets come from sources with same standard deviation.

If circumstances dictate that one of the sources *must* have a smaller standard deviation than the other in order to be of interest and the squared standard deviation from this source made the denominator of the ratio, there is but one chance in 20 of attaining the F ratio shown above if both sources in fact have the same standard deviation.

Remember that there is no way of knowing in advance which of two suppliers will be better — that is, have a smaller standard deviation.

IV

Number of Measurements, n, Required in Each of Two Groups to Have a Four-Out-of-Five Chance of Detecting Whether the Groups Have Different Standard Deviations

$\frac{\sigma_2'}{\sigma_2'}$	n
1.5	39
2.0	15
2.5	9
3.0	7
3.5	6
4.0	5

Note that the number of measurements depend upon the ratio, σ_1'/σ_2', of the true standard deviations.

The observed ratio of standard deviations for two domains is obtained by putting the value from the one expected to have the smaller standard deviation in the denominator. The observed ratio is judged by the critical values in III.

V

Factors t to Multiply the Standard Deviation of the Average Estimated From n Measurements in Order to Set up a 95% Confidence Interval for the Average

n	t
2	12.706
3	4.303
4	3.182
5	2.776
10	2.262
15	2.145
20	2.093
25	2.064
∞	1.960

VI

Given That Past Experience With a Process Has Provided a Good Estimate of the Standard Deviation σ' of the Output, the Table Shows the Number of Measurements Necessary to Detect Whether the Process Average Has Shifted by an Amount $\kappa\sigma'$ From a Prior Value

Shift in Average, $\kappa\sigma'$	Measurements Needed	
	4 Out of 5	9 Out of 10
$0.5\,\sigma'$	30	42
$1.0\,\sigma'$	8	11
$1.5\,\sigma'$	4	5
$2.0\,\sigma'$	2	3
$2.5\,\sigma'$	2	2
$3.0\,\sigma'$	1	2

If σ_1 is the average deviation for the prior process
σ_2 is the new average
σ' is the standard deviation
n is the number of observations

Compute $t = \frac{\sigma_1 - \sigma_2}{\sigma' \div \sqrt{n}}$

A value for t greater than 1.96 is evidence of a shift in the average of the process.

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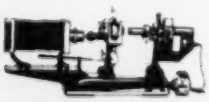

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Effective Quality Control Has Reduced Scrap Loss on Detail Parts to Six per Thousand

Fig. 1 — Interior of the "Flying Boxcar". Cargo hold is 8 ft. wide by 8 ft. high; it will carry 15 tons of matériel or 67 combat troops

Inspection Methods Keep Output of Flying Boxcars "on Target"

COMPLEXITY of modern aircraft has multiplied almost geometrically with successive increases in size, weight, speed and range, coupled with the perfection of instrumentation designed to enhance safety and improve maneuverability. In terms of metals and manufacturing techniques, the change from, say, only 15 years ago, has been little short of astounding.

This year marks the 50th anniversary of flight in the U.S. It may, therefore, be pertinent to take a look at what one leading aircraft builder is accomplishing, in the realization that, while possibly not typical of all segments of the industry, three unusual features will engage the interest of most metals engineers—namely a distinctive design of airplane with specialized functional characteristics; an original and efficient manufacturing-assembly concept; and a thorough system of quality control channeled into all phases of supply, production, assembly and testing.

This airplane is the "flying boxcar" or C-119.

By ARTHUR H. ALLEN
Technical-Business Consultant,
Cleveland

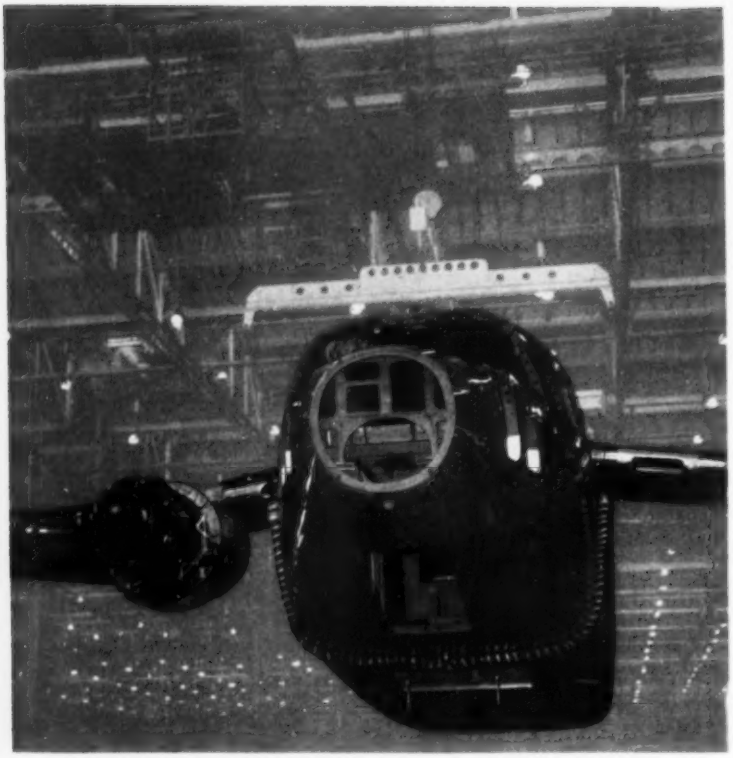


Fig. 2—Completed Center Section Is Moved by Overhead Trolley to Start of Final Assembly. Fluidity of production is achieved by reducing assembly operation to complete subassemblies mated through carefully machined fittings

Fairchild Aircraft Division of Fairchild Engine & Airplane Co., Hagerstown, Md., is responsible for this twin-engine, twin-boom cargo carrier. While the design is only about five years old, it already has progressed through six major modifications. It is a successor to the smaller C-82 "Packet," of which some 222 were built during 1946 to 1948; their characteristic blunt nose and fat, square-sided fuselage became closely identified with the movement of paratroopers and airborne military cargo.*

The C-119 now has a gross weight of 37 tons, of which 15 tons, or 67 combat troops, is cargo capacity. Length is 85 ft., height 27 ft., wing span 85 ft., and cargo hold 3095 cu. ft. (Fig. 1). It is powered by two engines of 3500 hp. each.

Loading and unloading of airborne boxcars is through large clamshell doors at the rear of the fuselage. Height of the tail and vertical clearance of the doors allows even tractor-trailers to be backed up to the cargo hold. Delivery may be by aerial drop; the clamshell doors may be left off and almost any cargo in the hold can be kicked overboard, attached to parachutes. Smaller doors in the rear assembly serve as an exit for paratroopers, who can jump without running the risk of hitting the tail surfaces.

In cargo service the ships have carried just about everything—10-ton bulldozers, fork-lift trucks, a complete asphalt paving unit, 19,000-lb. rolls of wire, a fully equipped fire crash truck, 3-ton generators, radio transmitting stations, patrol boats, artillery observation planes, jet engines, tractors, prefabricated buildings, snowplows, cement mixers.

FLUIDITY IN PRODUCTION

In converting manufacturing and assembly operations from the C-82 to the C-119, Fairchild engineers evolved a new and basic philosophy, geared to possible wartime demands calling for effective teamwork between engineering, tooling, purchasing, personnel and production departments, along with the customer—the Air Force or Navy. The aim was a better means of achieving fluidity of production within the framework of a limited supply of skilled labor, and of educating hundreds of suppliers to keep abreast of demands for quality and to provide a smooth flow of materials and parts to assembly points.

The principal factor in production of an airplane is elapsed time. Thus, if the "target" capacity of the Hagerstown plant is set at one C-119 per shift (approximately the current rate of assembly), no single component or subassembly must be in process for more than 8 hr. For instance, every ship requires, among other things, one center section, two tailbooms, two outer wing panels and two engines. No single portion of the conversion-assembly process can be permitted to run over 8 hr. elapsed time, since the fluidity of the production system depends upon the smooth flow of parts into subassemblies, then into major assemblies, and

*As a matter of record, the company has been engaged in aircraft manufacture since 1926, although until 1944 output was principally smaller high-wing cabin monoplanes, first introduced for use in aerial photography by Fairchild Aerial Surveys, Inc. Employment at Hagerstown plants now approximates 9100, which is more than the population of the town 25 years ago.

Efficient Scheduling of Subassemblies

finally into the aircraft itself. If a part takes more than 8 hr. to build, it is cut in half, completed by separate crews, and then mated.

Keystone of the C-119 is the center section, Fig. 2. Engines are attached to it, the fuselage is hung beneath, the tailbooms extend from its rear surface, and the outer wing panels protrude from its sides.

This section of the C-82 Packet was built in a steel jig about three stories high, with a framework of 1-ft. diameter tubing and general tolerances common to the toolmaking profession. However, because of its size, difficulties were experienced with warping and stretching. Beyond that, work frequently remained in the jig for a week or more, which would have meant that 14 such jigs would be required to maintain the desired production rate of one plane per shift.

So the C-119 center section was redesigned in two parts, assembled on a horizontal jig made up of two sections, one fixed and the other movable. To this jig were brought only subassemblies, completed and inspected, ready for mating. The only processing other than final assembly was in the fittings uniting the two halves. They were brought into the structure unmachined, and were milled to final precision dimensions after assembly. The center section was built as a low-tolerance operation except for the fittings, a technique which guaranteed smooth-mating parts, and reduced rejections and the possibility of built-in strains.

The same thinking was pursued throughout the entire production scheme. "Know-how" was built into the tools. Parts were designed for maximum use of automatic machinery like Erco riveters with which one workman can drill holes and drive rivets at a rate of 8000 a day (compared to 350 by a team of two hand riveters) and defective rivets amount to no more than 1%, as against 10 to 15% by hand riveting.

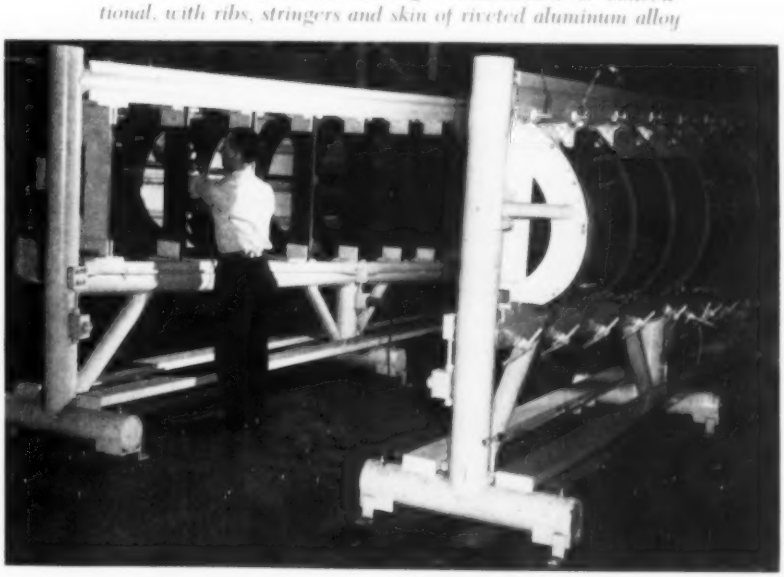
The entire plan, now in its second year of successful operation, calls for each part, subassembly and major assembly, to leave its position complete and inspected, ready to install without further check. For example, when the tail assembly—two tailbooms, two fins and rudders and a stabilizer-elevator unit—is mated to the center section, all cables have been installed and need only be hooked up to the controls in the cockpit. The old business of matching and splicing wires is eliminated by multipronged connector plugs. The landing gear unit, once ready for installation, has been assembled—wheels, tires, hydraulic system and all—requiring little if any subsequent adjustment.

As mentioned, the goal is to maintain rate-of-flow at all costs—and as to costs, the C-119 averages out to something like $10 per lb. contrasted with figures of $20 to $30 for many types of military planes.

A further interesting phase of Fairchild production planning is the "subcontractor's package". This contains not only the drawings of the required part but also detailed instructions and plans on tools, personnel, time schedules to be maintained—sometimes even training courses for the workmen. Other elements include studies of materials and where they may be purchased. Active subcontractors now number about 50; their indoctrination is a matter of company control.

A typical airframe model of the C-119 type contains over 8000 different items of raw material, customer-furnished and purchased, and Fairchild-purchased parts. They are processed

Fig. 3—Heavy Jigs in Which the Two Halves of Tailbooms are Assembled Prior to Mating. Construction is conventional, with ribs, stringers and skin of riveted aluminum alloy



through manufacture by more than 22,000 work orders, each having from four to six operations requiring inspection. Assembly is controlled by an additional 6000 inspection "sign-off" points. It becomes vital that each step in this progress insure the earliest possible detection of defects and prompt corrective action.

QUALITY CONTROL THROUGHOUT

Here is where quality control—QC—takes over. Fairchild has perfected an unusual organization to handle this work, supplemented by specialized equipment, methods and standards which encompass the entire range of chemical, physical, metallurgical, X-ray, electronic and hydraulic fields.

The quality control system bears the responsibility of limiting the quantity and cost of defective work as well as the normal inspection function of assuring the quality of the final product. The department, illustrated in graphic form in Fig. 4, is responsible to general management. It is headed by the quality manager, assistant quality manager, and a group of staff personnel. A brief summary of their respective responsibilities will indicate how they are integrated into over-all plant operations.

Inspection Engineering—This unit plans all inspection and shop processing standards affecting quality. They are based on customer (military) specifications, engineering requirements and laboratory tests which are combined into various types of printed instructions designed to handle specific problems. Assignments also include inspection of all experimental work, as well as material review for the entire plant. This group studies new inspection equipment and procedures prior to shop use.

Inspection engineering is further subdivided into five groups, as follows:

1. Methods and procedures, including manufacturing process specifications, inspection methods bulletins and inspection checking procedures.

2. Experimental inspection, consisting of activities ranging from prototype models of production aircraft to major assemblies, and back again to subassemblies and to detail parts. This group also constructs test rigs for major components, such as landing gears, so that operational "bugs" may be exterminated and cycle tests accomplished before installation.

3. Materials review is the name of a judicial function. When materials, parts or assemblies are found to be outside tolerance limits or damaged in the course of manufacturing or handling, a board of three persons is constituted to decide what shall be done about it. Each board includes one QC representative, one from Fairchild's engineering department, and one from the Air Force or Navy. Decisions fall into one of three categories—scrap, acceptable as is, or rework.

Similar boards also originate and publish daily reports, indicating the trend of rework and scrap in all departments of all plants, with departmental responsibility shown. Supervisors are thus able to curb abnormal rejections quickly.

4. Quality Control Laboratory—a name which actually includes a series of laboratories for chemical and physical testing, metallurgy, processing, X-ray, electronics, optics, instruments and hydraulics. The X-ray lab, for example, determines radiographic standards based on the first lot received for all Class A, Class A-1 and Class A-2 castings, then evolves the required X-ray procedures for a continuous-type of X-ray installation operated by Receiving Inspection. Certification of welders also is an important function of the QC lab. Other duties

Fig. 4—Pictorial Representation of Line and Staff Organization Functioning Under the Quality Control Manager

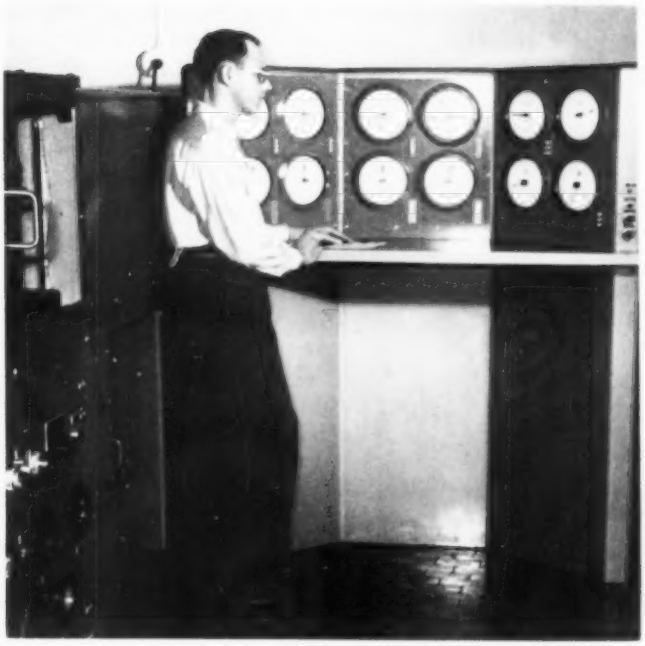


Fig. 5–Direct-Reading Spectrometer Is Used Regularly for Inspection of Incoming Materials. Instrument has 12 dials to show percentage of various constituents in samples of aluminum, copper, or magnesium, low-alloy steel or high-alloy steel

include the design and construction of test benches or special equipment to check the functioning of aircraft rapidly.

5. Flight test inspection includes re-inspection of any previously inspected system and installation as well as final inspection and certification that the airplane is ready for flight. Among detail checks is the functioning of engines, radio, radar, propellers, heating and ventilating and electrical systems. Final acceptance is concluded at this point.

Materials Inspection–General responsibility of materials inspection (item 2 on Fig. 4) is to insure that only acceptable items are received from vendors and subcontractors. Operations are classified into four major categories, briefed as follows:

1. Receiving inspection for all raw materials and equipment. Acceptance of raw material which is inspected by the Government at its source is based on dimensions. Otherwise, materials are checked dimensionally as well as for condition; further, a specimen is cut and examined for conformance with applicable specifications by the QC lab. Acceptable material is color-coded or stenciled and placed in separate bins, so that once it is released for manufacture it will fit exactly to work orders and drawings.

Many special devices have been installed in the QC laboratory in the interests of speed and accuracy for receiving inspection. Noteworthy is a Baird direct-reading spectrometer (Fig. 5) with 12 indicating dials showing percentages of Mn, Ni, Zn, Mg, Cr, Si, Fe, Al, Cu, Cb, Ti or Sn, and Mo or Pb in the sample under test. A five-position switch adjusts the machine's setting for analyzing samples of aluminum, magnesium, copper alloys, low-alloy steel, or high-alloy steel.

The spectrometer operates at 22,000 volts, 6.5 amp., and has a system of 30 photomultipliers. It is set up in its own room in which temperature and humidity are held within extremely close limits. A specimen of the metal to be tested is ground flat on one surface, positioned level under ¼-in. carbon electrode, and the current switched on. All that remains is to read the 12 dials for the complete analysis of the elements mentioned. It will be noted that two of the dials may be set to indicate either of two elements.

Ultrasonic testing of steel billets and such parts as aluminum wing spar chords is done regularly, with "defects" as determined by the Reflectoscope (Fig. 6) being further evaluated by X-rays in the QC lab. A separate X-ray machine, operated by receiving inspection and used primarily to examine castings, is a 140-kva. unit, fully conveyerized and with automatic film processing (Fig. 7). Trays of parts are moved under the tube by a ball conveyer table, passing to the unloading side after exposure. Testing has been clocked with as much as 5½ to 6 hr. "tube-on time" in an 8-hr. shift.

Receiving inspection also forwards to the QC lab representative pieces of equipment for aircraft; complete disassembly assures that the basic requirements of drawings and specification are being met by vendors.

2. Materials Stores and Warehousing. Inspectors handling this phase of the work are responsible for segregating materials so that problems will not arise involving weight, interchangeability or safety of the parts involved when the material is issued to production.

3. Spares and Shipping Inspection. Thorough

Fig. 6—Ultrasonic Testing Is Another Tool for Inspecting Incoming Materials. Internal defects can be located accurately and, if of significant proportions, are further evaluated by X-ray

checking of material shipped by Fairchild to subcontractors is done by this unit; it also verifies that shipments of spares to Air Force depots will comply with specifications.

1. Inspection at Vendors and Subcontractors. Qualified resident inspectors are maintained at all major subcontractors' plants, who observe all processing methods and are responsible for acceptability of all parts produced for the prime contractor.

Tool Inspection—Responsibilities here cover the accuracy of all precision measuring instruments, original and periodic inspection of all tooling used in manufacture, and interchangeability of parts and assemblies through coordinated tooling. Inspection work falls into three classifications:

1. Precision Tools. More or less conventional practices use gage blocks of three types. Master sets are used only for basic standards and are returned to the gagemaker every two years for calibration (or replacement if any are found more than 0.000,010 in. per in. in error). Inspection sets are used to check tool crib supermicrometers, vernier height gages, hand micrometers and the like. Tolerance on these gages is 0.000,025 in. per in. Finally, shop gage sets are placed in both manufacturing and inspection departments and used for setting comparators, sine plates and other measuring units requiring high accuracy. Their tolerance is 0.000,050 in. per in.

Both inspection and shop gage sets are inspected on a periodic schedule. Monochromatic light and optical flats are much used in connection with the master set; interference bands indicate dimensional variations as small as 0.000,003 in.

2. Detail Tooling. Inspectors are stationed in two Fairchild plants for inspection and maintenance of all tooling for manufacturing, such as layout templets, drill templets, milling and routing fixtures, hydropress dies, drill jigs and lathe tools.

Fig. 7—Trays of Aluminum Castings Are Moved Under 140-Kva. Production X-ray Machine Tube. Exposure and film processing are entirely automatic. This unit is operated by receiving inspection group

3. Assembly tools position and retain subassemblies in correct relation to one another while drilling, riveting or bolting. Data for initial acceptance of the tools are placed on the tool work order, operation sheet, or design drawings. Should the assembly tool be required to produce an item which must be interchangeable at attaching points, a tooling master is adapted to position and inspect the locators for the critical points.

Continued use of such assembly tooling will cause wear and misalignment of hinge locators, bushings or other positioning devices. To control accuracy, therefore, a definite inspection program assures that each tool is checked periodically. Regular inspection "logs" are kept on file by the chief tool inspector. A further check is made every 30 days for loose pins, bushings or clamps and other minor items connected with the assembly tools.

Parts fabrication inspection starts when raw material is issued to the shop. Particular emphasis is placed on all "trouble items" until corrections are made, as well as on those involving large quantities of parts on which dimensions are controlled by the operator.

Specific functions of the parts fabrication inspection division are settled on three groups—sheet metal, machine shop and processing. The first two are fairly obvious. Processing includes inspection after heat treating, aging, anodizing, plating, passivation and cleaning of components. Special clearance stamps release all parts to assembly.

In passing, it might be pointed out that effective quality control and inspection have combined to reduce monthly scrap loss on detail parts manufacture to 0.6% of the total number of pieces produced—a comfortingly low figure.

Assembly Inspection—The main assembly plant is divided into areas, each under constant surveillance of qualified inspection groups supervised at the foreman level. In general, these areas cover subassembly and major assembly divisions, electrical installations, and final assembly stations.

An indication of the effectiveness of quality control in the assembly plant is the way "squawks" are handled. The inspector has the responsibility for finding discrepancies in work in process; he has the additional task of initiating action to eliminate or reduce their frequency. "Squawks" (as Fairchild QC men call complaints) resulting from interior workmanship are eliminated by the close coordination of inspection and production supervisors. Other squawks requiring engineering action, tooling changes, changes in material or equipment, are handled through requests for investigation and correction to the shop liaison section of tool engineering.

Inspector Investigates "Squawks"

Returning briefly to the staff organization of QC, it was mentioned previously that statistical analysis is one phase. Statistical quality control methods are used wherever they will increase over-all efficiency without endangering quality standards. Application of X and R chart controls is limited in a plant producing only one complete machine per shift because of the relatively small quantities of identical parts presented for inspection at one time.

QC AND STAFF PERSONNEL

Another staff function is participation in monthly reports of what is called an "approved rating committee." Representatives of the Air

Fig. 8—Instrument Developed by Fairchild Inspection Engineers for Measuring Wall Thickness of Tubing by Electronic Means

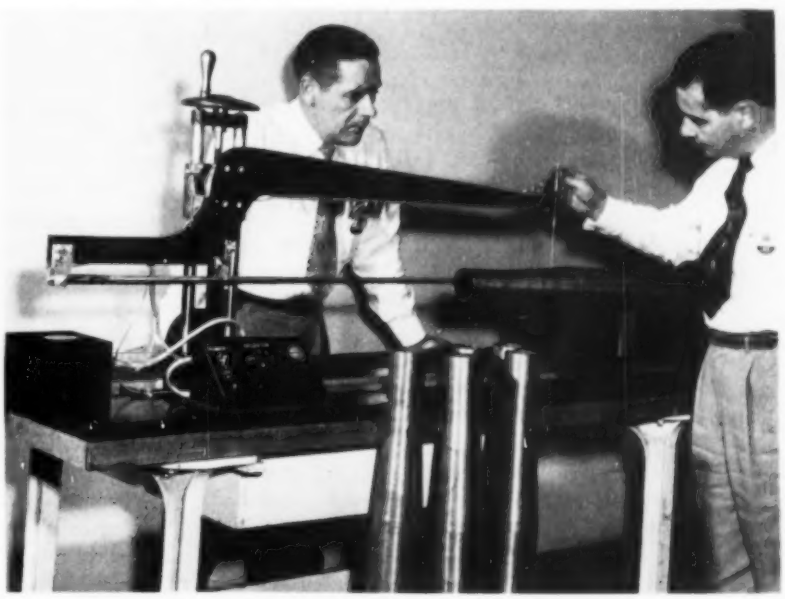


Fig. 9—Final Assembly Line for the C-119. Parts and subassemblies feed in from either side as the airplane moves ahead on its own landing gear

Force quality control branch and the Fairchild works manager's office also serve on the three-man committee which carefully reviews all phases of the operations of about 15 major production departments as regards the amount of scrap generated, amount of rework, whether schedules are being maintained, worker attitudes, departmental housekeeping and similar factors. Full reports are made every month and must be validated by department supervisors.

Finally the supervision of the department making the best showing is suitably rewarded with a dinner, entertainment or outing, while the unit with the poorest showing gets the "dirty pig" sign. Suffice to say, such a dubious distinction demands immediate corrective action on the part of the staff.

Quality control is a never-ending job. Closer tolerances, new methods of manufacture, new materials and improved equipment require constant surveillance and study. The goal is the elimination of human error as far as possible, and an approach to 100% inspection by making both supervisors and workmen conscious of the unique "tools" which quality control procedures offer them.

The problem is accentuated by the fact that airplanes are constantly becoming more intricate—more elaborate instrumentation, more complex electrical and electronic installations, more robot controls, more power, more speed, more maneuverability. To build them without extravagant costs and with certainty of functioning calls for a high degree of thoroughness and devotion to the job on the part of manufacturing, assembly and inspection crews.

Industrial Use of Radioactive Isotopes

COMMITTEE E-10 on Radioactive Isotopes of American Society for Testing Materials held a symposium in June in conjunction with the annual Society meeting at Atlantic City. What makes this meeting of particular interest to industry is the belief expressed that the theme of the symposium—"Radioactivity in A.S.T.M. Work"—will be important.

The all-day meeting was divided into a morning devoted to technical papers and an afternoon to demonstrations. Chairman S. E. Eaton of Arthur D. Little, Inc. arranged a diversified morning program covering some of the important applications of radio-isotopes. Subjects ranged from properties, uses, design, and instrumentation to management problems.

The afternoon session, organized by J. L. Kuranz, of Nuclear Instrument and Chemical Corp., was designed to demonstrate instruments and techniques having wide application in industry. The demonstrations included absorption and back-scatter beta gages, radiography, hydrogen-carbon ratio analyzer, and labeled compounds for tracer work. This was supplemented by an exhibit of representative instruments and complete equipment for radio-isotope work.

Two interesting questions were brought out in the discussion of the paper on "Applications and Uses of Radio-Isotopes" by C. D. Calkins of Battelle Memorial Institute. One question dealt with the use of activated oils or fuels containing vanadium in order to facilitate combustion studies. Mr. Calkins said that a suitable radioactive isotope of vanadium could only be obtained at present by cyclotron bombardment. There was some hint that the Van de Graaff machine at the High Voltage Engineering Laboratories may also be a source of active vanadium.

The second interesting comment on Mr. Calkins' paper started out with some questions about suitable methods for making steel containing radioactive C^{14}, and expanded to include mechanisms for studying complex carbides by selective tagging. The discussion covered problems incidental to steelmaking processes where radioactive tracers are used.

Efficient utilization of radio-isotopes in industrial studies is important from two points of view, namely the data which can be collected and the industrial hazard. Both these factors were extensively treated by G. G. Manov and O. M. Bizzell in "Design of Radio-Isotope Laboratories" and Donald R. Smith's presentation on "Training Personnel in Radio-Isotope Techniques". Some comment was made that a number of competent firms and individuals in this field offer services as consultants.

William L. Davidson, director of the office of industrial development of the U.S. Atomic Energy Commission, in "Management Problems Resulting From Radio-Isotope Utilization by Industry", pointed out that any firm entering into a contract with the A.E.C. for radio-isotopes must abide by certain rules and restrictions. Close inspection of the contract's fine print does not show any unusual restrictions, but the Atomic Energy Commission likes to know that a contracting company is fully aware of its liabilities.

An interesting observation was made by Dr. Davidson on the amount of this material actually getting into industry. The statistics usually quote the actual number of shipments of isotopes made from Oak Ridge. "Industry" makes a poor showing compared to "Medicine" and "Biology". In 1953 the applications for isotope uses in industry so far accounted for but one half of one percent of the total received by the A.E.C.'s isotopes division.

Two other observations were made by him which should interest top technical executives. First, it is important that management make sure that frequent and periodic checks and adequate records about the health of those handling radioactive materials are kept permanently on file. These records should be retained for at least 10 years—longer would be safer. Although present rules for radiation tolerance are based upon the best medical evidence, there is no assurance that long-time effects of radiation, real or fancied, might be the basis for a law suit.

The other observations made by Dr. Davidson dealt with the great number of patent applications on industrial uses and techniques of

By DON M. McCUTCHEON, Consultant in Engineering-Physics
Chairman, A.S.T.M. Committee E-10 on Radioactive Isotopes, Madina Beach, Fla.

isotopes. The question is, "Does the issuance of a patent necessarily restrict others from using this idea as long as it is used on the research and development level?" Many engineers believe that patent restrictions apply only where it can be shown that a profit was obtained. This idea is incorrect. Management would do well to check with their legal representatives if patented processes are involved.

O. M. Elliott's paper on "Application of Radioactive Techniques to A.S.T.M. Work" was essentially a survey made by John Kuranz. Isotopic dilution techniques occupied the largest portion of Mr. Elliott's expansion of this theme, and it appears, from comments heard at this meeting, that such techniques will probably occupy Committee E-10's early attention. The basic technique is remarkably simple. The mere addition of a small amount of radioactive isotope to a mixture containing nonactive elements will permit innumerable data-collecting schemes to be followed.

One of the more interesting variations of isotopic dilution is known by the formidable title "chromatographic autoradiography". The procedure allows quantitative evaluation in complex organic separations where the nonisotopic chromatogram provided only qualitative information. The opposite extreme in terminology involves a variation described as "popular mechanics" wherewith one can carry out a very simple analysis with low-cost or even improvized equipment and still obtain highly accurate analytical results.

One other interesting analytical scheme was described as a variation on the neutron activation method, and borrows a trick used by early spectrographers to obtain results of higher precision. It takes advantage of the wide variation in neutron absorption among the elements. Some trace elements present only in parts per billion can be accurately analyzed, the only requirement being that the trace element have a considerably larger cross section for neutron absorption than the major elements have. Such work can only be done in a reactor whose neutron flux is known quite accurately. Recently it has been discovered that the best way to do this is to expose the unknown simultaneously with an artificially prepared reference standard.

Tracer techniques are being used more and more widely in industry. Applications discussed by Mr. Elliott included the use of C^{14} in petroleum fractionating columns; addition of tracer elements to closed systems such as petroleum refining to evaluate performance; activating metals for wear studies; and simple tagging of batches merely for identification.

One of the most interesting demonstrations was provided by R. B. Jacobs of Standard Oil Co. of Indiana, assisted by H. M. Sullivan of the Central Scientific Co. The device is known as a "beta-ray hydrogen-carbon ratio analyzer." Dr. Jacobs pointed out that the three most important and basic factors in the study of petroleum are the chemical structure, the molecular weight, and the carbon-hydrogen ratio. The latter is difficult to determine by cumbersome and lengthy combustion methods. Newer petroleum refining techniques are aimed at the re-forming or hydroforming process, where a reduction of the hydrogen-carbon ratio is important to improve the anti-knock properties. Fast and accurate methods are necessary to measure this H-C ratio. The combustion method requires 4 hr. for 5% accuracy; the new analyzer gives the C-H ratio in 5 min. to an accuracy of $\pm$ 0.002% of the hydrogen.

J. Pennock of Tracerlab, Inc. demonstrated the beta-ray absorption and back-scatter types of thickness gages. It was apparent from his remarks and from discussion from the audience that manufacturers of such gages are aware of the different requirements of production-line installation from the more familiar laboratory instruments. There was no indication from Mr. Pennock's remarks, however, that serious competition will be offered by the beta-ray gage to the X-ray gage in the metal industry. The isotope gage, using favorable strontium^{90} as a source, is best suited for lightweight materials such as linoleum, paper and plastics, or for very thin metal foils.

Radiography with radio-isotopes is becoming quite common. D. T. O'Connor of the Naval Research Laboratory gave a comprehensive review of the best techniques. Particularly valuable to prospective users is his technique of using sensitivity standards, whereby physical factors are varied so as to maintain a standard sensitivity-density combination on the film. This procedure derives the most economical exposures; film interpretation is also much easier, since uniform sensitivity is maintained.

This review is intended only to give a brief report on what was considered by many experts as a most successful symposium on industrial utilization of radio-isotope techniques. The adoption of a working committee by the A.S.T.M. should do much to stimulate the practical applications of a useful tool, already widely utilized by scientific researchers.

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	Vanadium	Silicon max.	Carbon max.
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Correspondence

Migration of Cr and C in a Weld in Type 502

MILWAUKEE, WIS.

DURING a recent visit of H. G. Geerlings of Royal Dutch Shell Petroleum Co., of Amsterdam, Holland, he gave us a sample of 4 to 6% Cr (Mo) steel welded with 25-20 Cr-Ni electrode which had been heated at 1290 F. for 10,000 hr. As shown by Fig. 1, this joint exhibits some peculiarities which will be of interest to those who have placed similar materials in American refinery equipment. Dr. Geerlings told us that the abnormalities were not evident when the sample was examined after a 5000-hr. exposure.

Vickers hardness traverses and microexamination show five zones, stock to weld:

1. The 4 to 6% Cr steel stock; grains well polygonized; grain size No. 8 A.S.T.M.; some angular gray inclusions (hard refractory oxides); surface oxidized intergranularly about 0.004 in. deep. Vickers hardness 117 to 126.

2. Decarburized zone (A of Fig. 2) 0.10 to 0.30 in. thick, consisting of two or three very large grains with some smaller ones at the edge, appearing dark in Fig. 1 because of its high reflectivity. Vicker hardness 107 to 118.

3. Narrow white zone at weld junction (B of Fig. 2) where chromium diffused from high-chromium weld to the 4 to 6% Cr steel stock.

4. Somewhat darker etching layer along weld junction (C of Fig. 2) where carbon has diffused from 4 to 6% Cr steel stock into the 25-20 weld. Vickers hardness 266.

5. Columnar grained 25-20 deposit with sigma phase along subgrain boundaries in the bottom weld passes. Vickers hardness 203 to 216. (Dr. Geerlings said the hardness prior to test was 190 to 195.)

Neither stock nor weld electrode was stabilized—that is neither columbium nor titanium was detected by the spectrographic analysis.

Chemistry in detail is shown in Table 1 (wherein the first two columns represent analyses of original stock and weld furnished by Dr. Geerlings, and the others are spectrographic analyses made by us).

It would be interesting and valuable to hear from any other metallurgists who may have been able to examine similar welds after long service at high temperature. The sample we have is not large enough to make any tests for mechanical properties other than hardness, but we would expect considerable brittleness in the coarse-grained decarburized zone. Likewise, it has been our experience that a 25-20 weld which has been carburized can be very brittle in a tension test. *(Continued on p. 110)*

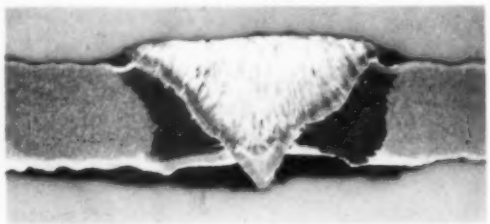
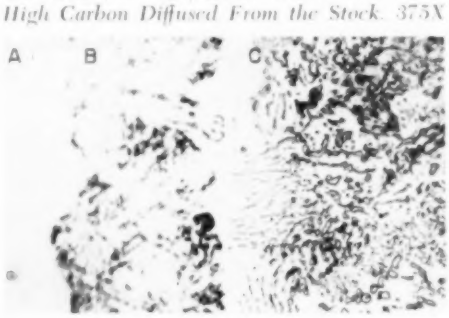


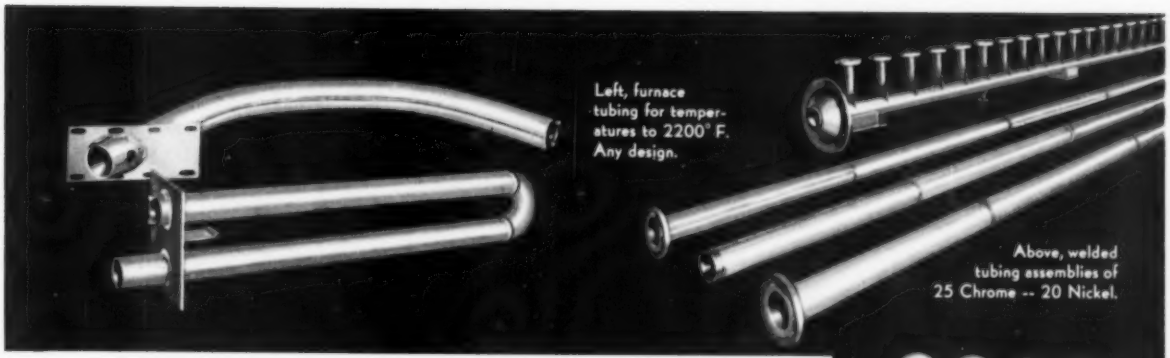
Fig. 1—Sample of 4 to 6% Cr Steel Welded With 25-20 Electrode. Five zones are shown, namely, steel stock, decarburized zone, narrow white zone at weld junction, darker etching layer along weld junction, and columnar-grained 25-20 deposit

Table 1—Comparative Analyses of Weld and Stock

	Wet Analysis		Spectrographic		
	Stock	Weld	Stock	Decarb. Zone	Weld
C	0.16%	0.11%	—	—	0.10%
Mn	0.39	1.70	0.48%	0.49%	1.43
Si	0.25	0.42	0.36	0.36	0.26
Cr	4.9	24.1	4.85	4.85	24.7
Ni	—	18.8	0.10	0.10	19.5
Al	—	—	0.17	0.15	Trace
Mo	0.70	—	0.59	0.59	Trace
Cu	—	—	Trace	Trace	Trace

Fig. 2—Weld Junction Showing (A) Decarburized Zone in 4 to 6% Cr Steel Stock, (B) High-Chromium Zone, Where Cr Has Diffused Into Stock, and (C) 25-20 Cr-Ni Weld With High Carbon Diffused From the Stock. 375X





Left, furnace tubing for temperatures to 2200° F. Any design.

Above, welded tubing assemblies of 25 Chrome -- 20 Nickel.

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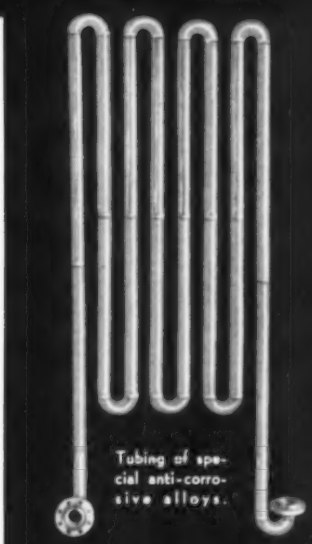

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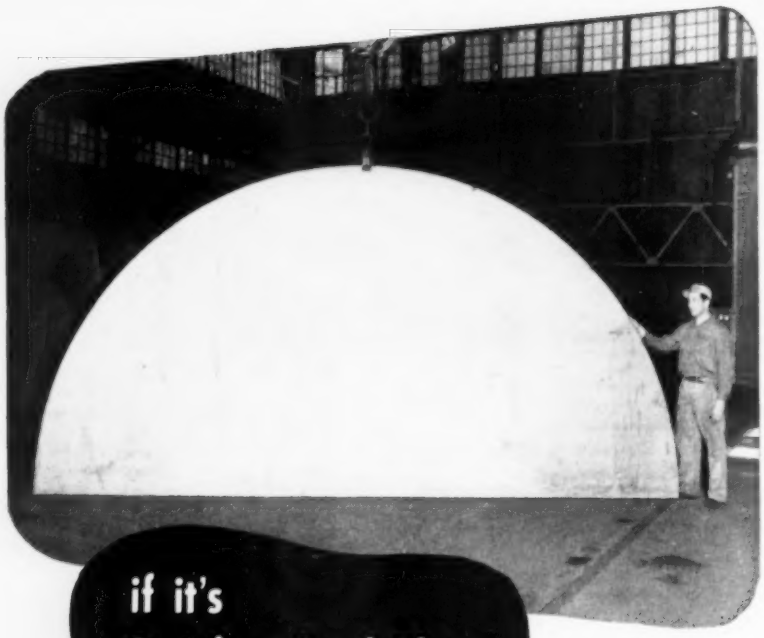

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Correspondence

(Continued from p. 108)

The usual 4 to 6% Cr steel (Type 502) used in America has 0.10% max. C rather than the 0.16% of Dr. Geerling's sample. His also is unusual in that aluminum has been added, possibly to reduce the air hardening tendency. Perhaps this aluminum has had some effect on the carbon migration, as we would not expect any from Type 502 stainless at 1290° F.

M. A. SCHEIL
Director, Metallurgical Research
A. O. Smith Corp.

Critical Points Unaffected by Magnetic Field

STILLWATER, OKLA.

The phenomenon, long known, that iron and low-carbon steels lose their permanent magnetism without change in crystalline structure at the so-called Curie point, 1420°F. (770°C.), has been used by heat treaters as a rough means of determining the quenching temperature and by scientists as a conditioner of their theories of the nature of magnetism. Some experimenters have worked on the theory that the Curie point (and perhaps the A_c and A_r critical temperatures or even the hardness of quenched higher carbon steels) might be changed if the heating were done while the metal was in an intense magnetic field.

We have investigated this last point in the Oklahoma Agricultural and Mechanical College in some test equipment wherein a ½-in. round could be heated or cooled at a uniform and slow rate while its ends were held by the poles of a large horseshoe electric magnet. Thus, temperatures and applied magnetic field (its strength and its direction) were under close control. Some 200 experiments were made on 1020 and 1050 steel specimens wherein the heating and cooling curves were compared with curves simultaneously recorded for a saddle of pure nickel resting on the test piece. We found no evidence that the temperature of the critical points of the steels was influenced by the presence or absence of a magnetic field.

B. M. ALDRICH
Assoc. Prof. of Mech. Engineering
Oklahoma A & M College

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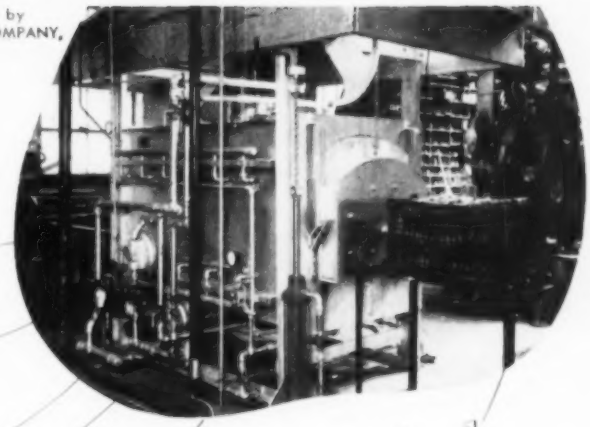

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Metal*	Temperatures—°F	Time—Minutes
Aluminum	750–1000	5 to 20
Brass & Copper	1200	20
Inconel, Monel, Stainless	1800–2000	20–30

*.015 to .125 thickness

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Personal Mention

J. Roy Gordon

William J. Priestley

J. Roy Gordon was recently elected vice-president and general manager of Canadian operations of the International Nickel Co. of Canada, Ltd. He graduated from Queen's University in 1920 with a B.S. in chemistry, and was associated from 1920 to 1929 with M. J. O'Brien, Ltd., as a research metallurgist. From 1929 to 1936 he was with the Ontario Research Foundation at Toronto, later serving as its assistant director of metallurgy. He joined Inco in 1936, and was appointed director of the research department established that year at Copper Cliff, Ont. Mr. Gordon was made assistant to the vice-president in 1941 and technical assistant to the vice-president in 1946. In 1943 and 1944 he was designated a member of the Ontario Mining Commission. Mr. Gordon is a director of the Ontario Mining Association, and served as president in 1949-1950. He is a member of the Canadian Institute of Mining and Metallurgy, the American Institute of Mining and Metallurgical Engineers and the Chemical Institute of Canada. He was the recipient of the 1948 Medal of the Canadian Institute of Mining and Metallurgy "for his contributions to process metallurgy in the smelting and refining of nickel, and improvements in metallurgical nickel recovery."

William J. Priestley, vice-president and director of Union Carbide and Carbon Corp., was honored recently by the Alumni Association of Lehigh University with the Lehigh Alumni Award, the highest award conferred by the Association. This honor was accorded Mr. Priestley "in recognition of extraordinary achievements in ferrous and nonferrous metallurgy, and of significant services as an iron and steel plant operator; in tribute to his leadership as an executive of one of the world's great chemical and metallurgical corporations; and in appreciation of his having contributed of his time, of his substance, and by his example to the advancement of the welfare and enhancement of the prestige of his alma mater." Mr. Priestley was graduated from Lehigh University with the degree of mechanical engineer in 1908. After distinguished service in the steel industry, and to the United States during World War I at the Navy's Armor Plant in Charleston, W. Va., he joined the Corporation in 1923 as a consulting metallurgist for Electro Metallurgical Co. He was elected president of Electro Metallurgical Co. in 1944. Mr. Priestley became a vice-president of Union Carbide and Carbon Corp. in 1945, and was elected to the board of directors of the Corporation in 1948.

Horace H. Lester was extended the most signal honor of the American Society for Testing Materials when at the annual meeting of the Society he was elected to honorary membership. Dr. Lester is principal physicist at the Watertown (Mass.) Arsenal. Among the ten long-time members of the Society receiving Awards of Merit for their outstanding service, particularly along technical lines in the committees, were **J. T. MacKenzie**, technical director of the American Cast Iron Pipe Co., Birmingham, Ala.; **R. E. Peterson**, manager of the mechanics division of the Westinghouse Research Laboratories of Westinghouse Electric Corp., East Pittsburgh, Pa.; and **Jerome Strauss**, who is vice-president of Vanadium Corp. of America, New York. **C. H. Fellows**, director of the engineering laboratory and research department of Detroit Edison Co., is the new vice-president of the Society. **T. F. Olt**, director of research laboratories at Armco Steel Corp., Middletown, Ohio, was elected to the board of directors.

G. A. Baker, vice-president of the Duriron Co., Dayton, Ohio, was elected president of the Alloy Casting Institute at its annual meeting held recently at Hot Springs, Va., succeeding **H. T. Harrison**, vice-president of the Duralloy Co., Scottdale, Pa. Elected to the office of vice-president was **C. K. Lockwood**, vice-president of the stainless steel and alloys division of Shawinigan Chemicals, Ltd., Montreal. **E. A. Schoefer**, Mineola, N.Y., was re-elected executive vice-president and treasurer. **K. E. Fitz**, of the Babcock & Wilcox Co., Barberton, Ohio, and **Thomas Rutherford**, of the Midvale Co., Nicetown, Philadelphia, were named as new members of the Institute's board of directors.

H. L. Ingram, Jr. has been appointed manager of the technical development department of the Air Reduction Sales Co., New York, a division of Air Reduction Co., Inc. Mr. Ingram has been with this company for 18 years, having been with the applied engineering department for five years, another five with the gas sales department and eight years as special representative.

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Personals

Jacob P. Schmidt and **James E. Koss** have accepted positions as plant metallurgists with the Monarch Steel Co., Chicago.

Myron DeHollander, formerly superintendent of General Electric Co. foundries and pattern shop at the Lynn (Mass.) River Works, was recently appointed manager of sales for foundry products at the Schenectady plant.

Harry W. Roberts, Jr. is now employed as a materials engineer in the aeronautical division of Minneapolis-Honeywell Regulator Co., Minneapolis.

S. Sarkar, formerly senior metallurgist of the Metal Corp. of India, Ltd., Manbhum-Bihar, India, has been promoted to assistant factory superintendent.

Donald F. North has accepted a position as research engineer for Jones & Laughlin Steel Corp. in Pittsburgh.

Truman S. Fuller, who served as president of the American Society for Testing Materials in 1951-1952, has been appointed consultant for the research and metallurgical departments of Heppenstall Co., Pittsburgh. Mr. Fuller recently retired after 42 years' service for the General Electric Co. at Schenectady, having started with that company in 1911 as a metallurgist in the research laboratory. In 1938 he was transferred to the works laboratory where he served successively as engineer of materials, assistant engineer, and engineer. Mr. Fuller was chairman of the Institute of Metals Division of the American Institute of Mining and Metallurgical Engineers in 1933, and is also a member of the British Institute of Metals.

Jay E. Barrett is now employed by the Aluminum Co. of America in Edgewater, N. J., after graduating from Lafayette College, Easton, Pa., with a B.S. degree in metallurgical engineering.

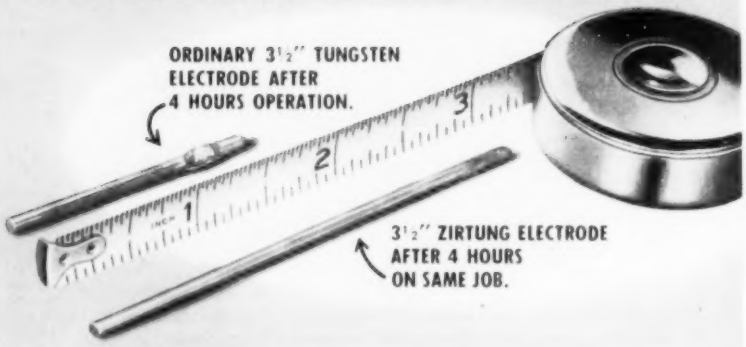
R. K. Paddock has been transferred by the Dow Chemical Co. from their Midland (Mich.) operations to the new magnesium wrought products plant being erected at Madison, Ill., as division leader in charge of melting and casting magnesium products in the technical department.

Orville L. L'Esperance has been transferred from Cockshutt Farm Equipment, Ltd., Brantford, Ont., as metallurgist, to Cockshutt Aircraft, Ltd., Renfrew, Ont., with a promotion to chief metallurgist.

Don A. Lawless, a specialist of 25 years' experience with light metals, has joined Sam Tour & Co., Inc., New York, as assistant director of the metallurgical department. Prior to joining the consulting firm, Mr. Lawless was employed at the Kaiser Aluminum and Chemical Corp., Oakland, Calif.

Donald Williams and **J. D. Hanawalt** were appointed vice-presidents of the Dow Chemical Co., Midland, Mich. Mr. Williams has been director of sales for the Company since 1949, and Dr. Hanawalt has been manager of the magnesium department since 1946.

ZIRTUNG Beats 'em all



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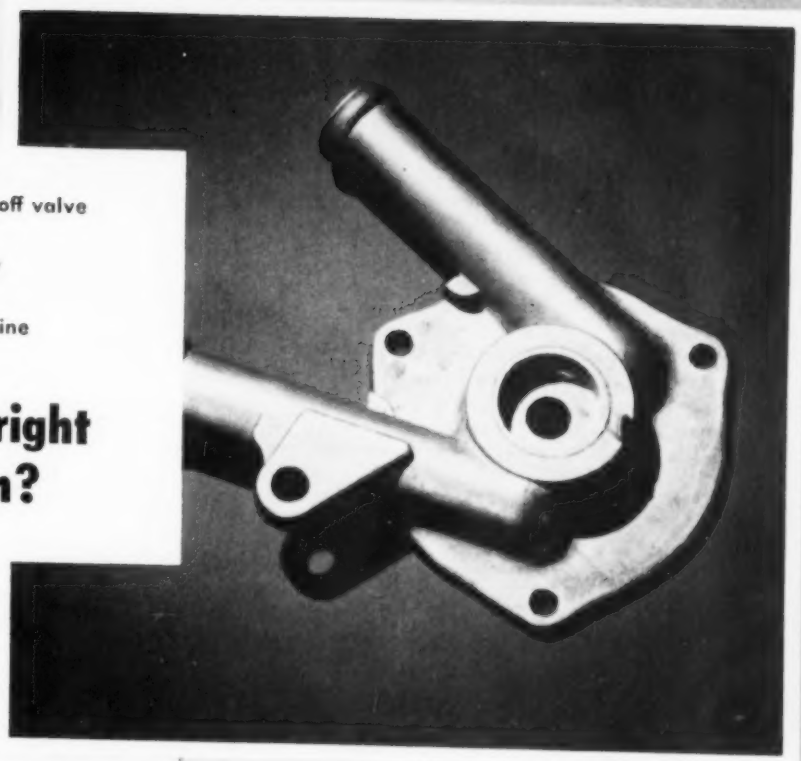

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What's the right X-ray film?

KODAK INDUSTRIAL X-RAY FILM, TYPE A

A big production run was scheduled. So to check casting methods, pilot castings were radiographed to detect any recurring porosities.

For these exposures, the radiographer used 70 kv, 54-sec. exposure at 36-in. tube distance—no lead screens—and Kodak Industrial X-ray Film, Type A.

This film is the first choice for examination of light alloys with short exposures at low voltages. It also has high contrast with fine graininess and speed enough to take full advantage of high kilovoltage equipment in radiographing thick or dense materials.

A RIGHT FILM FOR EVERY PROBLEM

Whatever your radiographic problem, you'll find the best means of solving it in one of Kodak's four types of industrial x-ray film. This choice provides the means to check castings and welds efficiently, offers optimum results with varying alloys, thicknesses and radiographic sources.

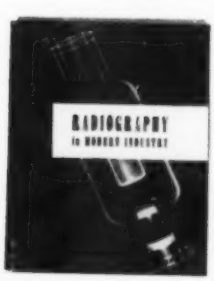
Type A—has high contrast and fine graininess with adequate speed for study of light alloys at low voltage and for examining heavy parts at intermediate and high voltages. Used direct or with lead-foil screens.

Type M—provides maximum radiographic sensitivity, with direct exposure or lead-foil screens. It has extra-fine grain and, though speed is less than Type A, it is adequate for light alloys at average kilovoltages and for much million- and multi-million-volt work.

Type F—provides the highest available speed and contrast when exposed with calcium tungstate intensifying screens. Has wide latitude with either x-rays or gamma rays when exposed directly or with lead screens.

Type K—has medium contrast with high speed. Designed for gamma ray and x-ray work where highest possible speed is needed at available kilovoltage, without use of calcium tungstate screens.

Radiography . . . another important function of photography



RADIOGRAPHY IN MODERN INDUSTRY

A wealth of invaluable data on radiographic principles, practice, and technics. Profusely illustrated with photographs, colorful drawings, diagrams, and charts. Get a copy from your local x-ray dealer—price, $3.

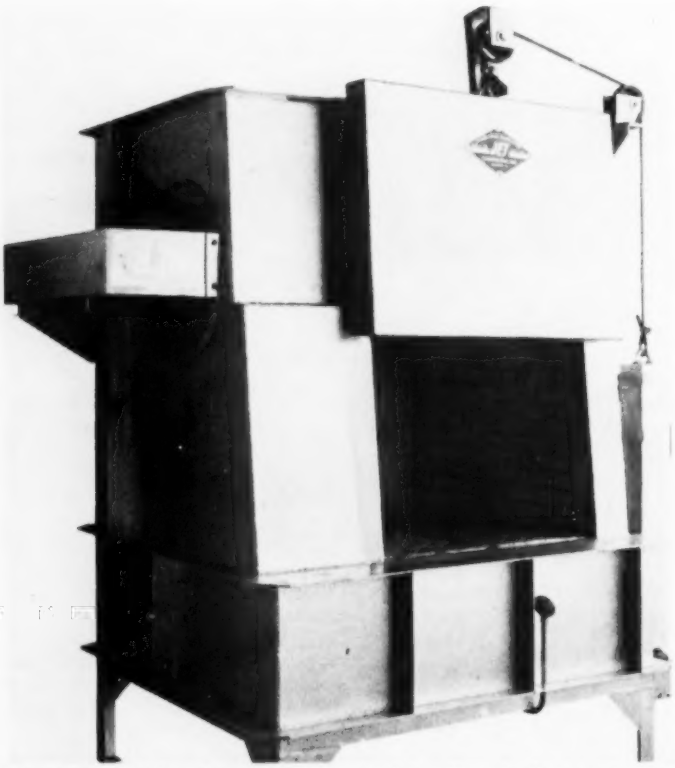
EASTMAN KODAK COMPANY
X-ray Division · Rochester 4, N. Y.

Kodak
TRADE-MARK

Personals

H. H. Zollar has been made general manager of Shenango-Penn Mold Co.'s centrifugal castings division at Dover, Ohio. In his new capacity, Mr. Zollar, formerly manager of sales, is responsible for all sales, plant operations, office management and other company activities on a local level. He started with the company 27 years ago as a machine shop clerk.

R. E. Sheffer, staff assistant to the general manager of the fabricating division of Aluminum Co. of America, Pittsburgh, since last September, is now manager of the company's Chicago Works. Mr. Sheffer graduated from Purdue University in 1925, joining Alcoa that same year. Two years later he became chief metallurgist at the Alcoa, Tenn., Works. In 1943 he became chief metallurgist and technical superintendent at New Kensington, and three years later works manager.



A small recirculating box type furnace for heat treating aluminum and steel castings. Accurate temperature controls, atmospheric burners, thick refractory lining and all the details that would go into a furnace many times this size, make this furnace a profitable investment for the industry it serves.

JET puts the same high degree of engineering skill into the design for a small furnace as it does into a whopping big one.

JET furnaces, big or little, are built to customers' specifications plus that extra quality of function and design which meets the Jet standard.

JET trade mark on a custom-engineered, built-by-JET furnace means a furnace built for years of productive service.

It's a good bet to see JET

JET COMBUSTION, INC.

INDUSTRIAL FURNACES • EQUIPMENT ENGINEERS

7917 So. Exchange Avenue • Chicago 17, Illinois

W. E. Benninghoff has been elected vice-president of the Ohio Crankshaft Co., Cleveland, continuing as general manager of the company's Tocco Division. Mr. Benninghoff was graduated from Case Institute of Technology in 1920 with a degree in electrical engineering. Until 1935 he was associated with the Cleveland Electric Illuminating Co. and in that year moved on to the Ohio Crankshaft Co. Mr. Benninghoff is a 25-year member of the American Society for Metals, and served as chairman of the Cleveland Chapter in 1932.

John W. Holzwarth has been appointed sales manager, industrial products division, for Salem-Brosius, Inc., Pittsburgh. Mr. Holzwarth had served as sales engineer for the company since joining the organization in 1951.

Wilton F. Melhorn, formerly assistant professor of metallurgical engineering at the University of Cincinnati, is now employed as metallurgist with Tube Turns, Inc., Louisville, Ky.

James F. Watson has recently graduated from the University of Michigan and is now with Dow Chemical Co., Midland, Mich., in the capacity of research and development engineer in the magnesium department.

Louis Silverman, formerly senior metallurgist at RCA Victor (a division of Radio Corp. of America) at Harrison, N.J., is now employed by Chromatic Television Laboratory at Oakland, Calif., as design and development engineer.

Arthur C. Willis, formerly with Magnaflux Corp. in Dallas, Tex., is now research metallurgist with Temco Aircraft Corp., also in Dallas.

Alvin E. Hope has been appointed Detroit district sales manager of Universal-Cyclops Steel Corp., after having been associated with the Detroit office for 14 years.

R. B. Preston has been promoted to supervisor of the chemical process division, covering the east-central region, of the Detrex Corp., with headquarters in Cincinnati.

Polaroid's "picture-in-a-minute" camera depends on BRASS

Snap the shutter on the famed Polaroid *Land* camera and a minute later you can have the processed, finished print.

When the Polaroid camera goes into action, a lot of precision-made brass parts go along with it. Each is of the composition, form, temper and finish most suitable for the purpose. Each contributes its share to a longer service life because of its durability, and its resistance to wear, fatigue and corrosion.

Little wonder that so many instrument makers depend on Brass... with so much of it from the mills of The American Brass Company.

THE AMERICAN BRASS COMPANY
General Offices, Waterbury, Conn.
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MAKERS OF

ANACONDA®
COPPER, BRASS & BRONZE

Personals

Austin Hiller has been appointed manager of product planning and marketing research of General Electric Co., Fitchburg, Mass. Mr. Hiller's new duties are to analyze and forecast trends in welding equipment, plan new and improved products, as well as to schedule their development, production and marketing.

M. E. Eaton is now engineering lecturer and head of the department of engineering at the University of Alabama.

Russell C. Nelson has resigned as mineral engineer at the Oak Ridge (Tenn.) National Laboratory, an atomic energy installation operated by Carbide & Carbon Chemicals Co. (a division of Union Carbide and Carbon Corp.), to accept a position as extractive metallurgist in the tungsten and chemical division of Sylvania Electric Products, Inc., Towanda, Pa.

A. V. Seybolt has been transferred by General Electric Co. from the Knolls Atomic Power Laboratory to the research laboratory, both located at Schenectady, N.Y.

J. P. Holt is now living in St. Louis, having been assigned the managership of the new office recently opened there by Basic Refractories, Inc. of Cleveland. Prior to joining Basic Refractories in 1950 as a sales engineer, Mr. Holt was superintendent of melting at the Midvale Co. in Nicetown, Philadelphia.

Carl E. Blass has assumed the position of plant manager at Talon, Inc., Woodland, N.C., after serving as manager of planning for the same firm at Meadville, Pa.

Dunston F. Boyd has accepted employment as a metallurgical engineer with Phillips Chemical Co., Pasadena, Tex., after graduating from the Colorado School of Mines. He is at present taking a military leave of absence to serve a tour of duty with the Corps of Engineers at Ft. Belvoir, Va.

John G. Scherer is now with the Dow Chemical Co. in the technical department at their Madison, Ill., magnesium plant after graduating from the University of Illinois with a B.S. degree in metallurgical engineering.

Joseph E. Parnell, who entered the Army in 1952 with a commission as second lieutenant in the Ordnance Corps and was stationed at Aberdeen Proving Ground, is now on his way to Europe.

E. F. Chojnoski is currently stationed at Picatinny Arsenal, Dover, N.J., as assistant metallurgist in the ammunition engineering section of the technical division of the Army.

Walter F. Carter has been appointed assistant general superintendent of the Riverdale (Ill.) plant of the Acme Steel Co. In addition, Mr. Carter retains his duties as director of technical services for the company. He joined Acme Steel in 1938, and since then has served as supervisor of the physical laboratory, metallurgist, assistant chief metallurgist and assistant to the works manager.

Stuart A. Smith was recently appointed district manager for Ohio by Firth Sterling, Inc., Pittsburgh.

Magic Dry

Worthy of your consideration!

THIS PAMPHLET and THIS SAMPLE

may save you thousands of dollars annually

by Eliminating { STAINING, DULLNESS, RUSTING and difficult cleaning problems }

Here are three typical uses:

PLATING — MAGIC DRY is a remarkable new product that helps eliminate rejects and increases production. In plating, MAGIC DRY is used in the rinse cycle in concentration of 1 - 2 ozs. for every 10 gallons of water 180° to 212° F. MAGIC DRY will eliminate plating stains and maintain the bright finish of the plated work.

TUMBLING — Four ozs. of MAGIC DRY per gallon of water applied to tumbled parts at room temperature immediately after tumbling retains the bright finish of the tumbled parts and thereby prevents them from rusting or staining.

CLEANING — When 1 oz. of MAGIC DRY is added to your alkali cleaner, vapor degreaser, or solvent cleaner, many difficult cleaning problems become a matter of routine.

HERE ARE 4 additional, new, proven products that will increase production and reduce costs!
COMPOSITION D—Rust preventative, solvent, detergent, cleaner, rancidity retardent.
MAGICLENE #2—Rust preventative, rust remover, cleaner and paint base.
BLACK MAGIC S.S.—Black finish for stainless steels, cast and malleable irons.
PIK-AIDE—Pickling addition agent.
Send for technical bulletins and samples.

Mitchell-Bradford

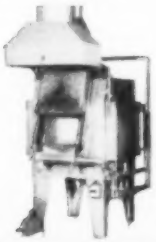
Send for a sample of MAGIC DRY and be convinced!

THE MITCHELL-BRADFORD CHEMICAL CO.
2446R Main St. Stratford, Conn.

QUALITY PRODUCTS OF CHEMICAL RESEARCH

Conveyor brazing furnace

Batch tempering furnace



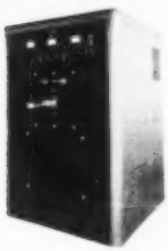
Controlled atmosphere hardening furnace (tool room)

Controlled atmosphere conveyor furnace (production)

a complete line of heating and melting FURNACES

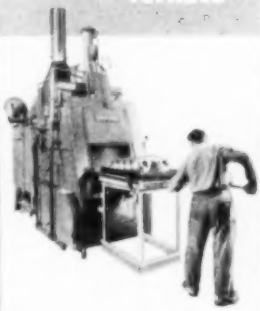
Production annealing and stress relieving furnace

Lindberg-Fisher 2-chamber induction melting and holding furnace

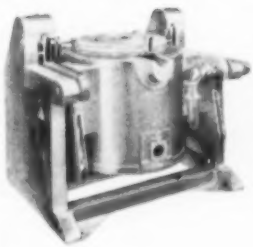


High frequency induction heating unit

Carbonitriding furnace



Fisher melting and holding furnace (gas or oil fired)



Lindberg Engineering Company manufactures a complete line of industrial heat treating furnaces, industrial melting furnaces, laboratory equipment, and high frequency induction heating equipment. Lindberg Engineering Company, 2448 West Hubbard Street, Chicago 12, Illinois. Write for details.

LINDBERG FURNACES

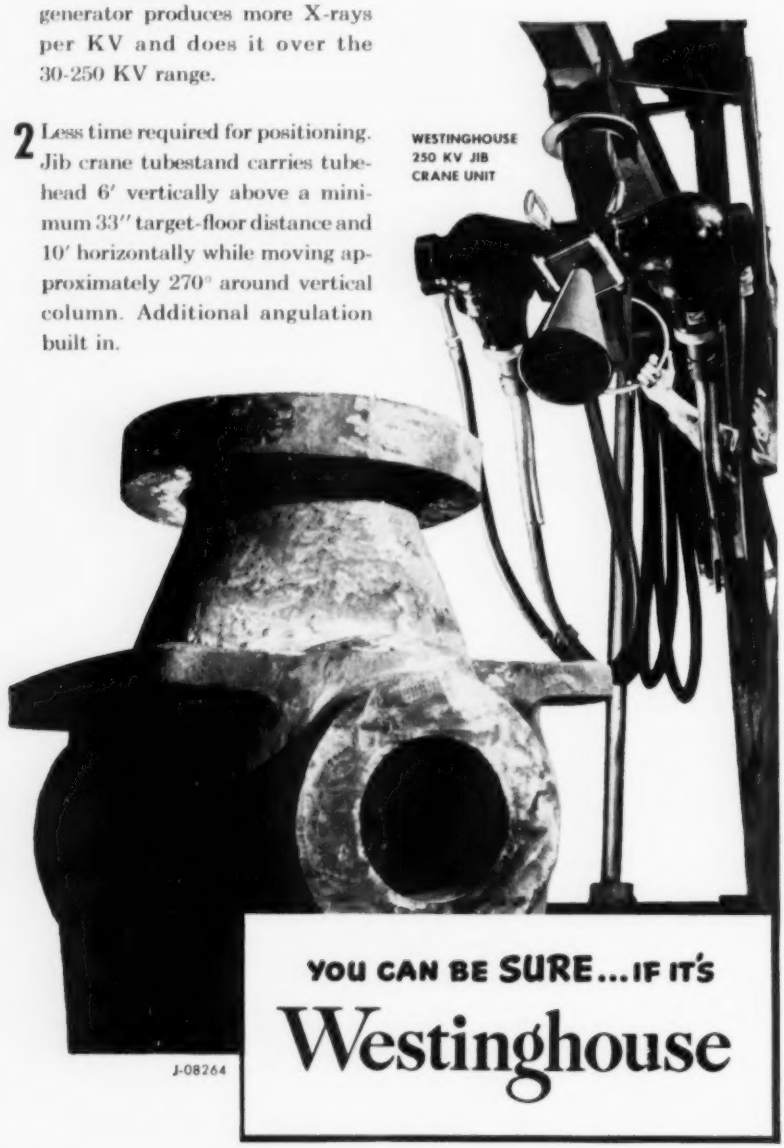
TOUGH JOBS *made easy*

At American Steel Foundries' plant in Newark, New Jersey, inspection of heavy steel castings is made easy by Westinghouse Industrial X-ray equipment. Reason: extreme *flexibility*.

1 Thick *or* thin materials take less time to radiograph. Westinghouse *Constant Potential* high voltage generator produces more X-rays per KV and does it over the 30-250 KV range.

2 Less time required for positioning. Jib crane tubestand carries tubehead 6′ vertically above a minimum 33″ target-floor distance and 10′ horizontally while moving approximately 270° around vertical column. Additional angulation built in.

Westinghouse assures you the finest, most flexible X-ray tools for your inspection jobs *plus* a coast-to-coast staff of technical experts. Call your Westinghouse X-ray representative or write Westinghouse Electric Corporation, 2519 Wilkens Avenue, Baltimore 3, Maryland.



WESTINGHOUSE 250 KV JIB CRANE UNIT

J-08264

YOU CAN BE SURE...IF IT'S

Westinghouse

Personals

Edward Kazuk, who graduated from the University of Illinois with a B.S. degree in metallurgical engineering, has accepted a position as research engineer with the Battelle Memorial Institute, Columbus, Ohio.

George E. Dieter, Jr., who received a doctorate in science from Carnegie Institute of Technology in June, has been called to active duty with the Ordnance Corps.

James C. Fulton, who was formerly a graduate student at Massachusetts Institute of Technology, is now research engineer with Allegheny Ludlum Steel Corp., Watervliet, N.Y.

J. Mocarski, formerly with the Canadian General Electric Co., Ltd., Toronto, is now employed as technical engineer with Sheepbridge Engineering Co., Ltd., Guelph, Ont. In his new position, he is in charge of inspection, all laboratories, and the metallurgy department.

Michael J. Cusamano is now back at the Gary Steel Works, a division of the U. S. Steel Corp., after a year's work at the corporation's research laboratory at Kearny, N. J. His present duties are those of turn foreman in the physical and metallurgical laboratories of the metallurgical division.

Damiam V. Gullotti, who graduated from Columbia University this summer, is now employed as principal metallurgical engineer in the mechanical metallurgy division at Battelle Memorial Institute, Columbus, Ohio.

W. A. Peterson is now employed as a sales and service engineer with the Crucible Steel Co. of America, Milwaukee, after having worked in a similar capacity as well as a district manager for the Allegheny Ludlum Steel Corp., Pittsburgh, for 12 years.

Otto F. Carl, who has been district sales manager of Universal-Cyclops Steel Corp. since the Chicago office was opened in 1927, continues his association with the company as special representative.

telling the story of 'dag' dispersions

Lubrication Troubles Above 500° F? Try This!

Use a **'dag'** dispersion. At high temperatures it has conventional lubricating agents beat a mile. Why? Because at ordinary metalworking temperatures it doesn't burn off, flake, or gum up. It successfully battles oxidation at every temperature up to 750°F.

'dag' dispersions of graphite form microscopically thin, *dry lubricating films* which fight friction beyond the burning-points of most oils. These dry films are unaffected by heat up to 750°F. . . . under some conditions up to 3000°F.

For more details on metalworking applications write for Bulletin No. 426-10 J.

* * *

Dispersions of molybdenum disulfide are available in various carriers. We are also equipped to do custom dispersing of solids in a wide variety of vehicles.

dag DISPERSIONS **Acheson Colloids Company,** Port Huron, Mich.
. . also ACHESON COLLOIDS LIMITED, LONDON, ENGLAND
Units of Acheson Industries, Inc.

try resin-bonded dry graphite films for permanent lubrication

INDEX OF ACP CHEMICALS FOR METAL PRESERVATION AND PAINT PROTECTION

METAL	OPERATION	ACP CHEMICAL
ALUMINUM	Cleaning	"DEOXIDINE" "DURIDINE" "ACP RIDOLINES AND RIDOSOLS"
	Preparation for Painting	"ALODINE" "DURIDINE" "DEOXIDINE"
	Protection from Corrosion	"ALODINE"
GALVANIZED IRON, ZINC, AND CADMIUM	Cleaning	"DURIDINE" "ACP RIDOLINES AND RIDOSOLS"
	Corrosion Proofing	"ZINODINE"
	Paint Bonding	"ZINODINE"
	Phosphate Coating, in Preparation for Painting	"LITHOFORM"
	Soldering Flux	"FLOSOL"
STEEL	Chromate Coating, in Preparation for Painting	"CROMODINE"
	Cleaning	"ACP RIDOLINES AND RIDOSOLS"
	Cleaning for Painting	"DEOXIDINE" "DURIDINE"
	Coating with Copper	"CUPRODINE"
	Drawing and Extrusion	"GRANODRAW"
	Paint Bonding	"CROMODINE" "DURIDINE" "GRANODINE" "PERMADINE" "THERMOIL-GRANODINE"
	Paint Stripping	"CAUSTIC SODA AND SOLVENT NO. 3"
	Phosphate Coating, in Preparation for Painting	"DURIDINE" "GRANODINE" "PERMADINE" "THERMOIL-GRANODINE"
	Phosphate Coating, to Protect Friction Surfaces	"THERMOIL-GRANODINE"
	Pickling with Inhibited Acids	"RODINE"
	Rust Prevention for Unpainted Iron	"PEROLINE"
	Rust Proofing	"PERMADINE" "THERMOIL-GRANODINE"
	Rust Removal—Brush, Dip, or Spray	"DEOXIDINE"
	Soldering Flux	"FLOSOL"

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CHEMICALS ACP PROCESSES

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Detroit, Michigan Niles, California Windsor, Ontario

Personals

John P. Ogilvie, associate professor of metallurgy at McGill University for the past three years, and formerly assistant professor there, has joined the stainless steel and alloys division of Shawinigan Chemicals, Ltd., in Montreal. He will be in direct charge of technical sales development through the study of new techniques and applications of stainless steel and alloys. Prior to joining the McGill faculty in 1948, Dr. Ogilvie spent two years with the Canada Bureau of Mines in Ottawa, and then spent three years at the University of California to obtain his Ph.D. degree in metallurgy while acting as a teaching assistant. He is also a member of the Canadian Institute of Mining and Metallurgy.

Harry Majors, Jr. is returning to the University of Alabama as research professor in the College of Engineering after a leave of absence while he was associated with the California Research and Development Co., Livermore, Calif.

Harry Stern, formerly metallurgist with the experimental foundry of the National Bureau of Standards, has been transferred to the metallography laboratory section of the Naval Gun Factory, Washington, D.C., in the same capacity.

Wm. H. Strickler, a graduate of the University of Michigan with a B.S. degree in metallurgical engineering, is now employed by the Dow Chemical Co. as production engineer in the magnesium foundry in Bay City, Mich.

W. Theodore Highberger has resigned as departmental metallurgist at the Massillon (Ohio) plant of the Republic Steel Corp. to take a position in metallurgical research for the Naval Proving Ground at Dahlgren, Va.

Charles K. Munn, formerly treasurer of the Edgcomb Steel Corp., Hillside, N.J., was elected vice-president and treasurer of the company at a special meeting of the board of directors recently after having been with the corporation for 26 years.

Case No. 42

Kemp Immersion Heating Gets Top Results for Signode Steel Strapping Company

How Signode Steel Strapping Co. tempers 650 feet of steel strap every minute

At the Signode plant in Sparrows Point, Md., turning out up to a thousand miles of steel strap daily calls for fast, efficient production line techniques. One highly important phase in the final processing is the tempering bath. Here, Signode called on Kemp Engineers to supply the 15 ton, gas-operated Immersion Melting Pot shown above. Now steel strap is uniformly tempered at the rate of 650 feet per minute.

Kemp Offers More Advantages

By installing Kemp Immersion Heating, Signode benefits in many ways. Unlike underfired pots, Kemp pots are *not* subject to *periodic* and expensive shutdowns . . . won't crack or break. They operate *continuously* at maximum heating efficiency with a ***substantial*** savings in fuel costs. Offer a greater heating surface, faster heat recovery, lower dross formation, even lower room temperatures. At the same time, this Kemp unit enables Signode to eliminate costly temperature override and open flame fire hazards.

Let Kemp Solve Your Problems

These same advantages apply to all types of melting or heating operations. Whether you are engaged in tempering, annealing, descaling, coating, etc., you can rely on Kemp Immersion Heating. Why not find out how Kemp Engineers can help you, save you money?

This 10 ton oval pot is typical of the many Kemp installations now in use. Features Kemp Carburetor, part of all Kemp equipment, to deliver complete combustion . . . without waste . . . without tinkering. One-pipe air and fuel feed reduces installation costs, simplifies maintenance.

For more complete facts and technical information, write for Bulletin IE 11 to **C. M. KEMP MFG.CO., 405 East Oliver St., Baltimore 2, Maryland.**

KEMP OF BALTIMORE

IMMERSION MELTING POTS

CARBURETORS • BURNERS • FIRE CHECKS
ATMOSPHERE & INERT GAS GENERATORS
ADSORPTIVE DRYERS • SINGEING EQUIPMENT

✓ check the price

✓ check the analysis

✓ check the performance

and you'll specify

MUELLER BRASS CO.

tuf-stuf®

aluminum bronze

check the price—TUF-STUF, the Mueller Brass Co. series of aluminum bronze alloys, can be supplied at prices below those of similar alloys. Whether you buy TUF-STUF in rod shapes, forgings or screw machine products you'll save money because these alloys are priced right, machine better and last longer.

check the analysis—TUF-STUF alloys are a high copper base series containing from 9% to 13% aluminum and varying amounts of iron, nickel and manganese. They do not contain zinc and, therefore, are not subject to dezincification. TUF-STUF alloys are available in several grades with a chemical composition, suitable hardness and mechanical properties for many different applications.

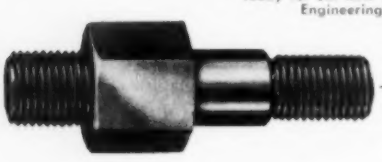
check the performance—TUF-STUF alloys are light and strong—about 8% lighter than cast bronze and almost as strong as steel. They have a low coefficient of friction as well as good bearing and mechanical properties. They not only retain these properties but resist oxidation at the high speeds and high temperatures of modern production equipment. They will withstand strong acid attack or the effects of brackish waters and are highly resistant to corrosion.

These alloys can be hot-forged into relatively intricate shapes . . . need little or no machining . . . and the smooth, bright surfaces eliminate costly finishing.

MUELLER BRASS CO.

PORT HURON 20, MICHIGAN

For complete information, write today for our new TUF-STUF Engineering Manual.



90

Quality Control in Copper Refining*

THE WRITER deals in some detail with the controls employed in melting and casting fire-refined copper, phosphorus-deoxidized copper, cadmium copper, tellurium copper, and silver-bearing copper. The selection of raw materials and charge make-up are considered in relation to the type of furnace and the metal or alloy to be produced. Contamination from fuels, furnace launders, ladle linings and from charge materials must be controlled. A detailed description of control methods employed during fire-refining of copper in large oil-fired reverberatory furnaces, and its subsequent casting into horizontal wire bars, serves to illustrate the various problems.

In the production of vertically cast billets and rolling slabs, pouring speed, funnel shape and size, oxygen content, mold temperature and size, all affect the quality of the final casting. Even from this brief summary it will be seen that the production of high-quality copper wire bars, billets and rolling slabs is a complicated matter requiring the most careful and exacting control and the supervision of men who are intelligent and keenly interested in their work.

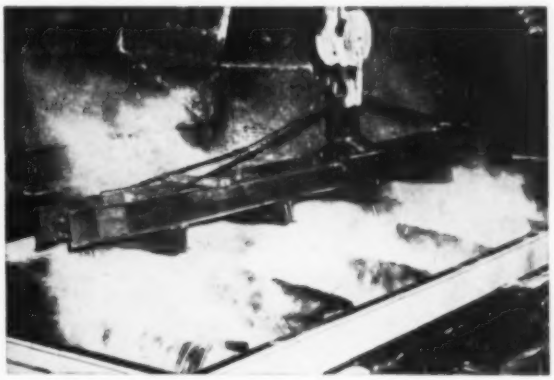
Blister copper for the United Kingdom comes almost entirely from the copper belt of Northern Rhodesia. It analyzes copper 99.5%, lead 0.0012%, iron 0.011%, sulphur 0.066%, bismuth 0.0018%, arsenic 0.0012%, antimony 0.0003%, nickel 0.0062%, cobalt trace, selenium 0.0017%, tellurium 0.0001%. Since bismuth, nickel, selenium, tellurium, cobalt, silver and gold are not normally removed from the copper, these elements must be strictly limited. Antimony and arsenic can be substantially eliminated by special fluxing techniques. Tin and lead can be reduced to reasonable limits by excessive slagging, but not without losses in copper and reduction in refractory life. Iron, sulphur, zinc, cadmium, and aluminum are fairly readily removed.

(Continued on p. 126)

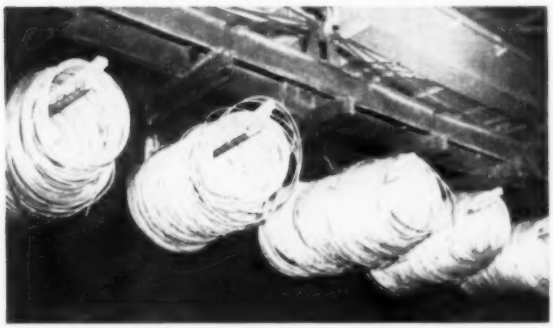
*Digest of "The Control of Quality in Melting and Casting Copper and High-Conductivity Copper-Base Alloys," by J. Sykes; *Journal* of the Institute of Metals, March 1953, p. 351-363.

Descaling 5 tons of stainless wire *IN 15 MINUTES* with VIRGO® Descaling Salt

10-MINUTE IMMERSION in molten bath of Virgo Descaling Salt at 900°F. loosens scale. The bath is self-regenerating, and produces no toxic fumes. Immersion time and temperature are flexible, need not be watched closely.



WATER QUENCH removes much of the loose scale. The steam generated by immersing the hot metal in the water further loosens scale by its blasting action. The work is thus prepared for the final acid dip.



THREE-MINUTE DIP in dilute acid removes the now soluble scale. The work is ready for a rinse or hosing to wash off the acid. **Result: a chemically clean surface—no pitting, etching or metal loss.** TOTAL TIME—15 MINUTES.

VIRGO DESCALING SALT—Producers and fabricators of stainless and alloy steels use Virgo Descaling Salt to quickly, positively remove scale produced by hot rolling, forging, extruding, casting, annealing.

VIRGO MOLTEN CLEANER—quickly, positively desands and degraphitizes castings; removes grease, dirt, chemicals, paint, enamel, rubber, atmospheric corrosion and other impurities.

This process can be used on steel; castings; forgings; fabricated parts; material to be salvaged. It employs simple equipment, and is easily adapted to your production methods.

SEND FOR THESE BULLETINS
—Get the whole story on Virgo Descaling Salt and Virgo Molten Cleaner—what they are, how they work, their advantages, how they fit your operations, and the Hooker services you enjoy as a user of the process. Send for these bulletins today.

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Quality Control in Copper Refining

(Continued from p. 124)

A typical analysis is given of electrolytic copper of 99.98% purity. The elements other than copper are best determined by the quartz spectrograph, although sulphur and selenium are not suited to this method. The direct-reading spectrograph has shortened the time for getting results.

Emphasis is placed on the need for careful segregation of scrap. It should be marked and baled at once to avoid mixing. In loading the furnaces, light scrap should be charged first to form a cushion, then heavier scrap and blister. Small scrap should be baled tightly, and must be stacked so as not to deflect the flame onto the furnace roof or sidewalls, thus causing incomplete combustion.

Melting followed by fire refining is carried out in reverberatory furnaces with either pulverized fuel or oil; capacities run from 50 to 180 tons, and the melting cycle is complete in 24 hr. The copper will only maintain its "pitch" for a short time, and for this reason 5-ton portable oil-fired furnaces are used.

Recently a 6-ton oil-fired furnace of the reverberatory tilting type has been installed by the Enfield Copper Refining Co., Ltd. From this furnace 40 to 50 tons of metal a day are cast vertically into 1000-lb. cakes. Charging times are eliminated in the usual sense, for the furnace melts at the same time it is being charged. The more refractory copper alloys are melted in rocking arc furnaces.

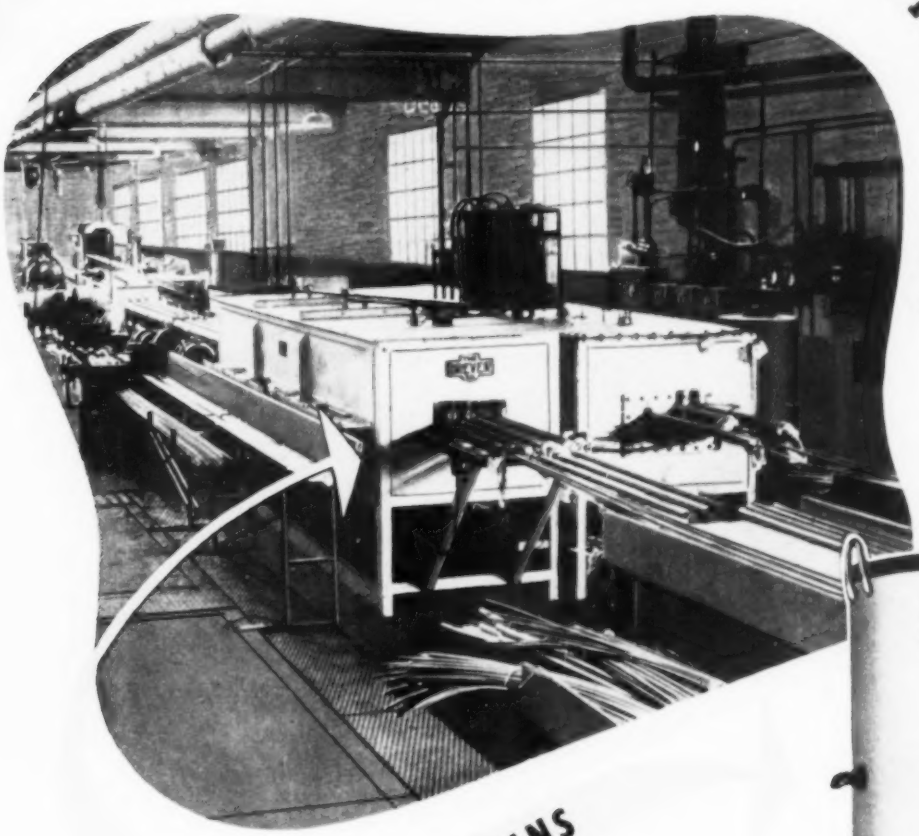
Two types of oil are often employed for fuel. During meltdown, when high heat input is required, and during part of the oxidation period, heavy fuel oil is used. This may contain as much as 2.75% sulphur, but with oxidizing conditions and efficient combustion no serious pick-up occurs. When the oxygen content reaches about 0.6%, the burners are replaced by burners for light oil. The sulphur content of the light oil should be less than 0.20%, but 0.50% has been used.

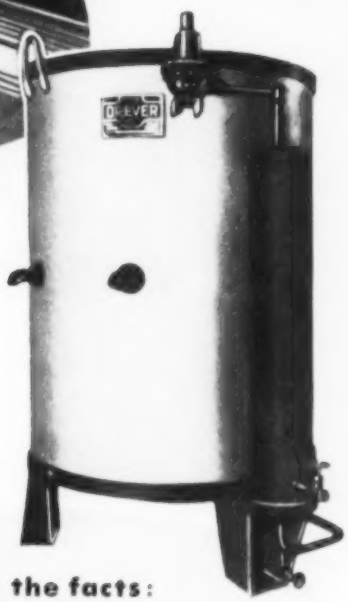
In the fire-refining process a blow tank is used to introduce soda-ash and lime into the furnace under the surface of the metal, so as to eliminate arsenic and antimony. It is evident that the refining process calls

(Continued on p. 128)

bright annealing

OF STAINLESS STEEL TUBING at 2050°F





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5—No pickling required before drawing
6—No pickling after finish anneal
7—Furnace can be gas or electrically heated
8—Capacities up to 2000 lbs./hour
9—Tubing from capillary size to 2½" O.D.

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6

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LIVES with HEAT...

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and likes it!

This new metal greatly widens the scope of engineering design where conditions of intermittent or continuous high temperatures in oxidizing atmosphere are combined with abrasion, and compressive or tensile loads.

WHAT is Kentanium?

Chiefly titanium carbide (and small percentages of other refractory metal carbides), with nickel "binder". Uses neither tungsten nor cobalt. Hardness: Up to 93 RA. Weight: ⅔ that of steel.

WHAT can it do?

Resist thermal shock, withstand oxidation and abrasion, retain great strength at high temperatures (1800°F and above).

WHERE is it in use?

Successful applications include: Valves, valve seats, reduction crucibles, anvils for spot welding, hot extrusion die inserts, bushings, thermocouple protection tubes, flame tubes, furnace tong tips, balls for hot hardness testing, nozzle vanes and blades for jet engines, and many others.

WHAT forms are made?

Tubes, rods, bars, flats by extrusion process. More complex parts by machining from pressed slugs before sintering; extremely accurate parts by grinding to required tolerance after furnace sintering.

HOW can you use it?

This remarkable new metal, available in many "grades" to meet specific combinations of imposed conditions, can best be adapted to your high temperature problem by cooperative effort. Our engineers will be glad to discuss how you can get best results from Kentanium.

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KENTANIUM

HEAT-RESISTANT, HIGH-STRENGTH, LIGHTWEIGHT CEMENTED TITANIUM CARBIDE

Quality Control in Copper Refining

(Continued from p. 126)

for great attention to a number of small details.

An interesting point in the production of horizontally cast wire bars is the use of bone-ash for mold dressing. Defects common to this process, for which remedies are suggested, include moisture holes, oil holes, bone-ash inclusions, cracks, sand inclusions, high set, dimensional defects, laps, heat holes, and rolled or sloppy edges.

In the casting of vertical shapes the molds are made of solid tough-pitch copper castings, water cooled, and 5-ton, oil-fired, portable furnaces are used for melting. It is essential that the metal do not splash on the sides of the mold, and it is poured through a refractory-lined funnel, the size of the orifice being determined by the size of the casting being made. Defects are shadow cracks, cold sets, and pitting.

The high-conductivity alloys include phosphorus-deoxidized copper, 0.05% silver-bearing copper, titanium copper, cadmium copper.

Both physical and chemical methods of inspection for refined copper shapes are given, and a detailed method is shown for conductivity testing in control of refining.

An appendix lists the composition of etching reagents, and includes methods of chemical analysis for specific elements.

HAROLD J. ROAST

Hard, Strong Ti-Fe Alloys*

PROBABLY a metallurgist's first speculation about titanium alloys is whether they are usefully heat treatable like steel, since (like iron) titanium undergoes a transformation near 1650°F. This paper by an Australian scientist is among the first to present some evidence on that question.

Certainly the heat treatment response is there. Mr. Worner, for example, shows a base hardness of about 345 Vickers for an 8.7% binary iron alloy; quenched from 1750°F.

(Continued on p. 130)

*Digest of "Heat Treatment of Titanium-Rich Titanium-Iron Alloys," by H. W. Worner, *Journal* of the (British) Institute of Metals, Vol. 80, 1952, p. 213 to 216.

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In the years ahead, Vanadium Corporation will continue to keep ahead of the growing demand for vanadium throughout American industry—producing increased quantities of Vancoram Ferrovanadium for both military and civilian use.

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Hard, Strong Ti-Fe Alloys

(Continued from p. 128)

and aged for 15 min. at 825°F., the hardness jumps to about 630 on the same scale.

Whether such response is industrially useful is another matter, the resolution of which will have to await the publication of considerable ductility data in conjunction with hardness and strength values. The adjacent table from Worner's paper gives some of the first published data on this subject.

Properties of Binary Ti-Fe Alloys

Property	2% Fe		3.8% Fe	
	Soft*	Hard†	Soft*	Hard††
Vickers hardness	260	395	305	445
Ultimate strength	100,000	205,000	135,000	240,000
Elongation in 1 in.	10%	4%	7%	3%

*Cooled from 1750 to 1200°F. in 15 min.; held for 6 hr. and then water quenched.

†Water quenched from 1750°F., and tempered for 15 min. at 825°F.

††Same as above except tempered at 930°F.

Tensile strengths at the 200,000-psi. level with only 3 to 4% elongation do not have much current utility. On the other hand, the combination of a minimum design tensile of 160,000 psi. and 10% elongation would now be of industrial interest. Reports of investigations to attain such combinations and comparisons of hot worked and annealed, quenched and aged titanium alloys, would be most welcome.

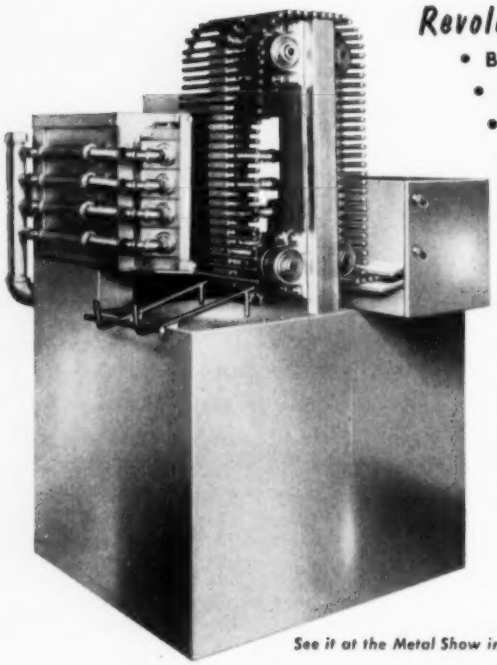
This is not meant at all to disparage the value of Worner's present paper which, with others on titanium from the Baillieu Laboratory of the University of Melbourne in Australia, constitutes a major contribution to the knowledge of this new and useful metal.

The constitutional diagram used as background for Worner's present paper is taken from a previous publication by the same author. It is a typical eutectoid system. Consistent with a recent *Metal Progress* paper, "Today's Titanium Alloys" (February 1952, p. 73), Worner shows that alloy-lean titanium compositions, quenched from the all-beta region, develop a Widmanstatten structure, whereas alloy-rich compositions retain beta. He reports the dividing composition to be 3.8% iron with Kroll titanium powder arc melted under argon (which had an unalloyed hardness of 215 Vickers).

Worner investigated the hardness changes of several binary titanium-iron alloys as a function of the time and temperature of elevated-temperature aging. Typical results for an 8.7% iron alloy, water quenched from 1750°F. to a retained beta structure having a hardness of about 400 Vickers, are as follows: (*a*) Aged at 430°F. there is little change. (*b*) Aging at 680°F. brings the hardness up to 530 Vickers within a few minutes, presumably by trans-

(Continued on p. 132)

New Automatic G.A.S. "Hot Rod" End Heating Unit



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For example: The Model 8-4 (Illustrated) heats the ends of ½" rod to 1900°F at the rate of 900 pieces per hour—a heating time of only 50 seconds per rod. Automatic hopper feed and conveyor supply "hot" pieces at a steady rate, all alike, up to temperature at one end, and perfectly cold at the other (handling end). Heats sections up to 4" in length. Standard models available for bar stock ¼" to 1½" in diameter; hopper adjustable for 6" to 24" length.

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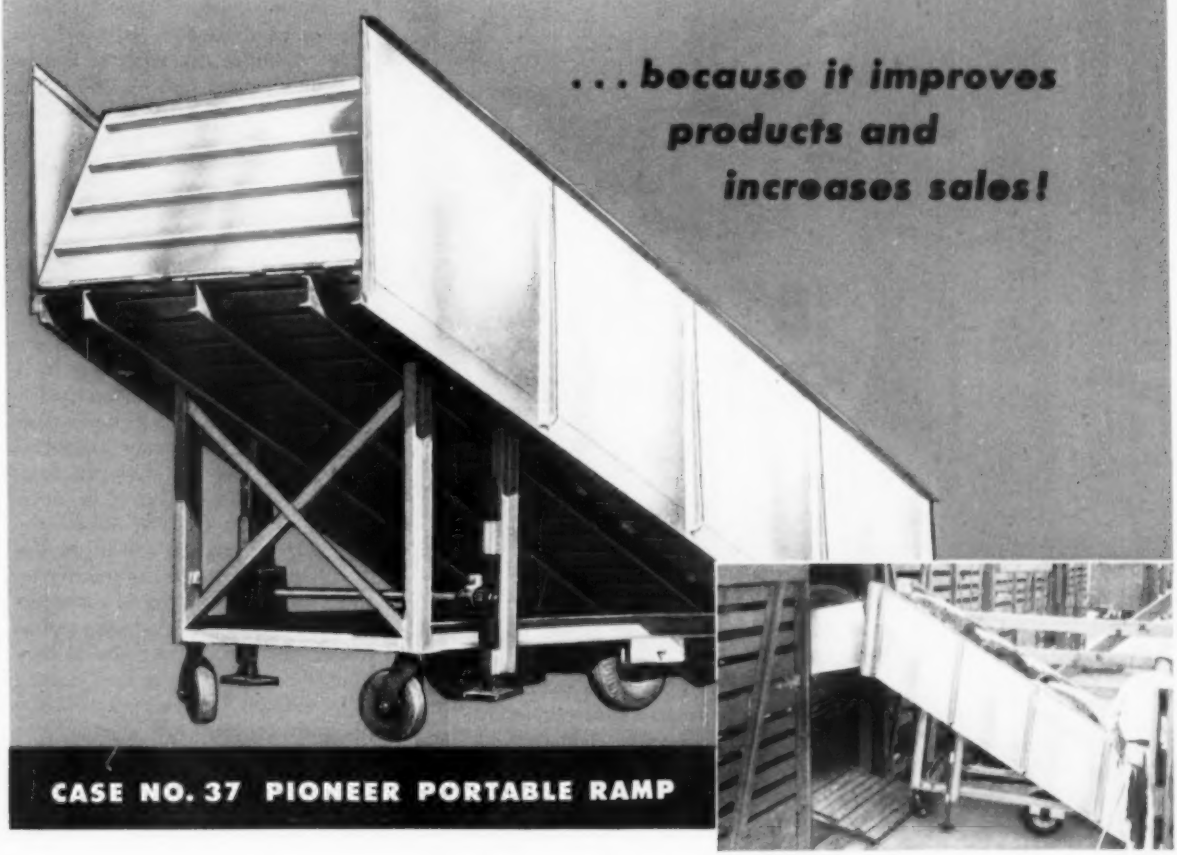

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Furthermore, aluminum does not rust, rot, mildew or otherwise deteriorate from exposure to weather. These aluminum ramps do not require painting or other protective maintenance—they are much easier to clean and thus more important savings are effected. These are the kinds of dividends you can realize by using aluminum.

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Hard, Strong Ti-Fe Alloys

(Continued from p. 130)

formation of some of the retained beta to alpha; thereafter the rate of hardening tapers off, reaching a maximum of about 580 in 10 to 15 hr. (*c*) Aging at 825°F. gives a maximum of about 630 Vickers within 1½ hr.; thereafter the hardness lowers, approaching 560 in 15 to 20 hr., presumably as the transformed alpha overages.

Worner refers to the foregoing processes as "age hardening." This terminology is correct, but perhaps it would be worthwhile to make a clean-cut distinction between "precipitation hardening" (which is also used synonymously with "age hardening") and "transformation hardening." When referring to the hardening process in a titanium alpha-beta alloy, then, one would use the terms "transformation hardening" or "transformation aging." This would preserve the distinction which has long been made between the *transformation* hardening effected by austenitizing and quenching a medium-carbon steel, and the *precipitation* hardening effected by solution heat treating (for example, to dissolve 0.025% carbon in ferrite) and quenching a low-carbon steel.

The basis for the distinction lies in the nature of the phase with which the hardening is associated: In transformation hardening it is an allotrope (or at least a transition stage in the formation of an allotrope) of the matrix, and the latter may almost entirely disappear in the process. In precipitation hardening it is an intermediate phase or another element, and the matrix never even approaches disappearance in the process. WALTER L. FINLAY

Survey of Developments in Hard Metals *

THE FIELD of pyromerged (sintered) hard metals has grown up as a practical operation, wherein each manufacturer has evolved a production technique from empirical or practical considerations within the individual operation. Also, ap-

(Continued on p. 134)

★Digest of "Recent Developments In Hard Metals," by E. J. Sanford; *Alloy Metals Review*, Vol. 8, March 1953, published by High Speed Steel Alloys, Ltd., Widnes, England.

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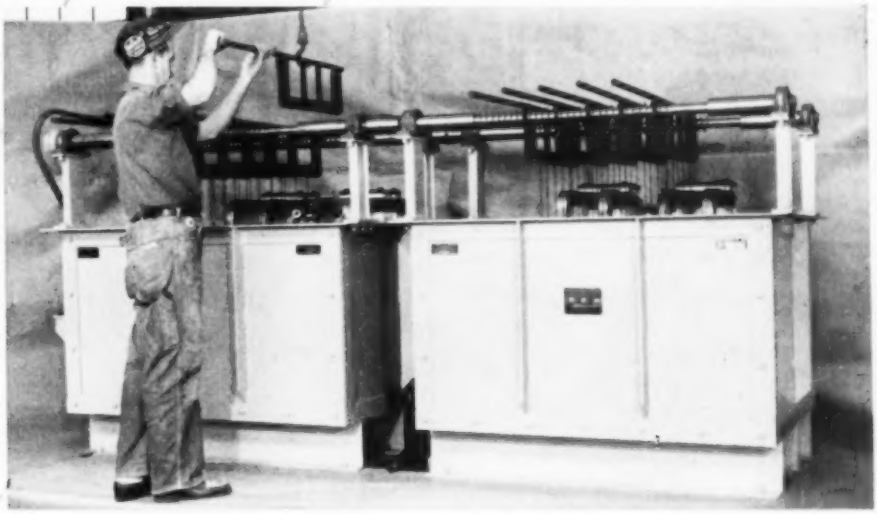

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Because temperatures of liquid salts can be controlled within two to three degrees, you can get the same close tolerances in your heat-treating as you demand from your machine shop. And you can get it batch after batch, week in and week out because Houghton Liquid Salt Baths are pure and double-refined for stability.

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Ready to give you on-the-job service . . .

Survey of Developments in Hard Metals

(Continued from p. 132)

plication of the various hard metal grades (principally tungsten carbide alloys) is much dependent upon empirical knowledge.

The desirability of accumulating theoretical background for novel practical application has been felt, and new investigation into the tungsten-cobalt-carbon system has been undertaken. Recent work of Rautala and Norton on the elevated temperature areas of this system (Co-W-C) presents two new ternary phases formed in peritectic reactions. Confirmation of the critically narrow working composition range for the commercial alloys is discussed in this paper.

A summation of Gurland and Norton's research on the role of the cobalt phase in tungsten carbide-cobalt alloys is included. Gurland and Norton leached out the cobalt electrolytically with hydrochloric acid and found that all alloys, irrespective of initial cobalt content, disintegrated. From this, Gurland and Norton conclude that a continuous skeleton of tungsten carbide is not formed during sintering, and that the action of the cobalt is, in fact, one of "cementing." The dilatometric reactions of tungsten carbide-cobalt alloys during solidification of the liquid phase are inconsistent. Expansion takes place in low cobalt (5%) alloys, while higher cobalt (> 7.5%) alloys contract. Other physical data on the cobalt-tungsten carbide binary system are also presented in this paper of Gurland and Norton.

Trent's new theory of metal cutting, covering the function of titanium carbide additions to tungsten carbide-cobalt alloys for use in steel cutting, is discussed at length. The formation of liquid solutions of tungsten carbide-cobalt alloys and steel at elevated temperature is known. During machining of steel with a tungsten carbide-cobalt alloy, the chip friction on the tool top induces a temperature of approximately 1300°C. (2375°F.); this produces a fusing of tungsten carbide and iron, and rapid erosion occurs. Titanium carbide and tungsten-titanium carbide do not form such liquid solutions at any appreciable rate, and also have a high thermal conductivity. This latter property reduces the average temperature of the tool tip, while the former property reduces considerably the erosion of the tool tip by the chip flow. Trent also investigated the formation of "build up" near the cutting edge.

The Kennametal explosive hydrostatic pressing method assures uniform compacting of powder before working or heating.

Use of hot pressing is seen to be advantageous for reclaiming large, expensive dies. The work of Kuzmick and of Kieffer on hot pressing contributes considerable knowledge of reaction rates in this type of operation. Pressure of approximately 1000 psi. is used with either direct electric mold heating or induction heating, and the final temperature reached approximates that for sintering cold pressed material. Loss of cobalt is a continuing problem for hot press operations.

(Continued on p. 138)

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- **SOFT SOLDERING**
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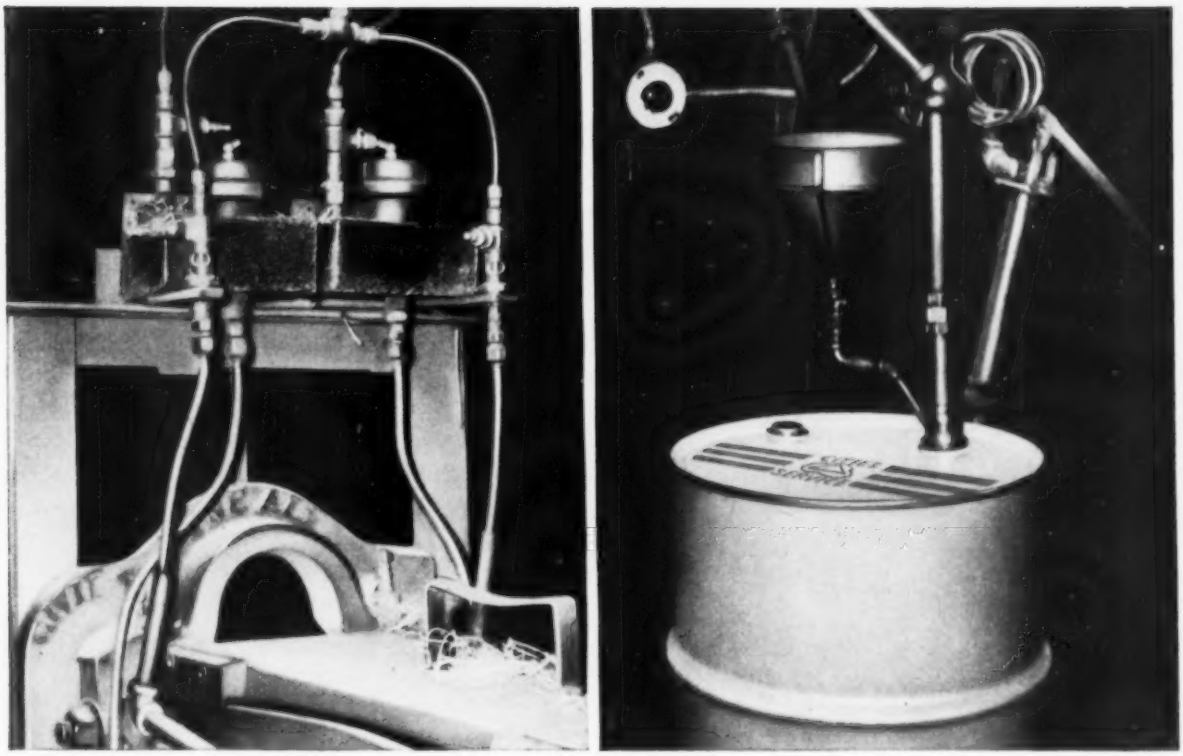

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- minimum hardness was increased from 50 to 60 RC
- variation in hardness was reduced from ±5 to ±2 RC

on AISI C-1064 STEEL

Tinnerman Products, Inc., Cleveland, Ohio, manufactures a large variety of spring clips and spring fasteners of the type pictured at the left. These parts range in thickness from .01 to .062 inches and are all made of AISI C-1064 spring steel.

Normal heat treating practice calls for heating to 1600 deg. F. in a controlled atmosphere. The parts are held at this temperature for approximately ½ minute, then are transferred by a shaker-type conveyor into the quenching bath, which is held at 120 to 125 deg. F. After quenching, the parts are tempered at 700 deg. F.

When Tinnerman used a conventional quenching oil, hardness varied from 50 to 60 RC—too low and too variable for suitable performance characteristics. Examination of the steel revealed that in all cases it was within specification limits.

After investigating a number of other quenching oils, Tinnerman Products discovered one that is outstanding—Gulf Super-Quench. Tinnerman Products is now quenching all of these parts in Super-Quench with remarkable results. Hardness is never lower than 60 RC and averages 62 ± 2. This improvement was obtained without any change in quenching temperature, degree of agitation, analysis, or grain size.

If you, too, are looking for ways and means to increase the efficiency of your quenching operation, it will pay you to investigate the advantages of Gulf Super-Quench. Write, wire, or phone your nearest Gulf office.

Gulf Oil Corporation · Gulf Refining Company

Pittsburgh 30, Pennsylvania

GULF SERVES INDUSTRY

A scratch that could be costly . . . but isn't

Scratch or damage the surface of most "corrosion-proof" fume ducts . . . and you expose a non-resistant structural material. Corrosion gets its start. This is not true, however, where you use ATLAS AMPCOFLEX®.

AMPCOFLEX is an unplasticized, rigid polyvinyl chloride. It is both corrosion-proof and a self-supporting, structural material in itself. If scratched, only more AMPCOFLEX is exposed . . . it is corrosion-proof throughout. Neither normal wear nor corrosive fumes and splash can necessitate the costly maintenance common to other type constructions. AMPCOFLEX resists most acids, salts, alkalies and standard pickling and plating solutions.

Aside from the advantages of AMPCOFLEX as a material . . . ATLAS fabrication is an important consideration. Backed by over thirty years experience in corrosion-proof materials and constructions, ATLAS has set up special shops and personnel exclusively for AMPCOFLEX Fabrications. ATLAS can assist you in design and engineering; and furnish any type, any size structure capable of withstanding both chemical and physical abuse. In addition, ATLAS can furnish pipe, pipe fittings and the necessary accessories.

STANDARD STOCK DUCT SIZES AVAILABLE in both round and square sections in lengths up to 16 feet. Write for information.

For Complete Data, write for Bulletin 9-1.
ATLAS MINERAL PRODUCTS CO.
MERTZTOWN, PENNA.

. . . self-supporting, corrosion-proof structures

ATLAS Ampcoflex

FABRICATIONS

Survey of Developments in Hard Metals

(Continued from p. 134)

The work of Williams in the hot pressing of pure tungsten carbide (WC) indicates that grain growth occurs in the absence of cobalt to produce a structure very similary to that noted in certain WC-Co alloys. The grain growth phenomenon has not yet been satisfactorily explained by a precipitation theory of tungsten carbide from a liquid phase. Recrystallization appears to be a more likely mechanism for grain growth. The work of Kieffer and Kolbl in investigating the impregnation of sintered WC and WC-TiC compacts with alloys of cobalt and tungsten receives comment. Certain of these impregnations result in erosion of the base material, and others do not.

The hard facing technique of "flame plating" (Linde Air Products Co.) gives a very thin deposit of tungsten monocarbide and multicarbide phases (Co_3W_3C). The wear resistance of the coating is high and the base material (steel, cast iron, aluminum, copper, brass, bronze, titanium, magnesium) is unaffected in the application. Apparently the process prevents oxidation during the deposition, and no alloying occurs between the base metal and the deposit. Coatings between 0.0005 and 0.020 in. thick can be applied to most base metals (except chromium and carbide tools), and the base material temperature should not exceed 200°C. (392°F.).

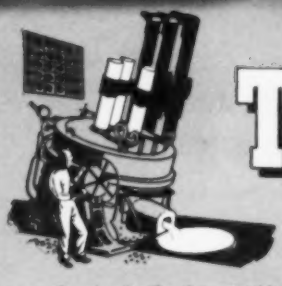
A. D. Stevens

Productivity of Die-Casting Industry*

Output of zinc and aluminum pressure die castings per head of population in the United States is 250% that of the United Kingdom, while in gravity die casting the output is 70% of that in Great Britain. A comparison between productivity levels was impossible but American production was estimated at 30 to 40% higher for zinc alloy die casting and 20 to 25% higher for aluminum

(Continued on p. 140)

★Digest of "Productivity Report" of the British team which visited 18 American die casting plants. *Engineer*, Oct. 31, 1952, p. 569.

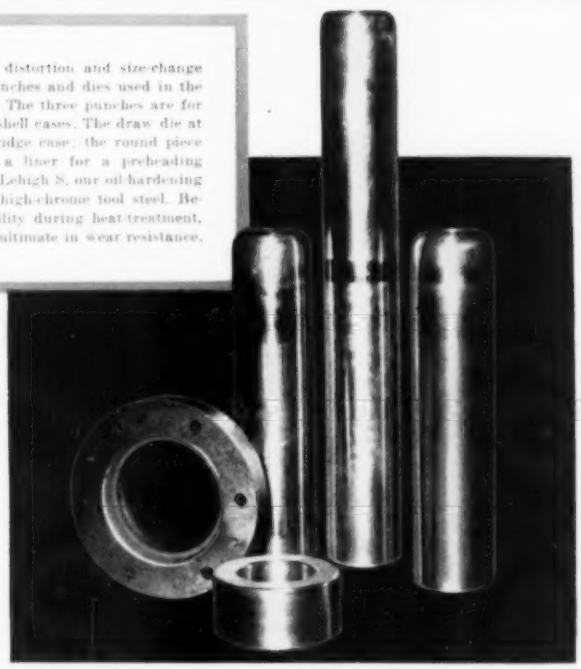


Tool Steel Topics

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

Only the minimum of distortion and size-change can be tolerated on punches and dies used in the cold-extruding of steel. The three punches are for cold-drawing 105 mm shell cases. The draw die at left is for a 5-in. cartridge case; the round piece in the foreground is a liner for a preheading die. All are made from Lehigh S, our oil-hardening grade of high-carbon, high-chrome tool steel. Besides its inherent stability during heat-treatment, Lehigh S provides the ultimate in wear resistance.



There's no such thing as a non-deforming tool steel

Shrinkage, growth, and warpage—all occur when a tool is heated for hardening. There just isn't a tool steel which is "non-deforming" in the absolute sense of the term.

It's downright discouraging when an accurately machined tool or die emerges from the heat-treating furnace with its shape distorted or its dimensions way beyond the allowable tolerances. Yet, this experience is quite common.

In many instances the change in size caused by heat-treatment is not so great as to cause any trouble. Proper grinding, to remove scale and to obtain exact tool dimensions, is often all that is necessary. However, excessive warpage or size change can make it costly, even impossible, to restore a tool to the proper shape or correct dimensions, either by grinding or by corrective heat-treatment.

It's obviously important for both tool-makers and heat-treaters to understand the causes of distortion and how it can be controlled within reasonable limits. The design of tools, the grade of tool steel used, and heat-treatment procedures—all these factors have a bearing on the degree of distortion which will occur.

Warpage, for example, is usually a factor associated with the geometrical shape of a tool and with the thermal stresses produced by lack of uniformity in heating or cooling operations. The composition of a tool steel has very little to do with the occurrence of warpage.

On the other hand, the growth or shrinkage of tools is the result of volume changes caused by the hardening operation. Each grade of steel has certain characteristics of inherent distortion. And it varies considerably with the composition. Carbon tool steel, for example, has a distortion "factor" of approximately .002 to .004 in. on the plus side. A high-carbon, high-chromium grade, such as our Lehigh H, has a factor of only .0005 in., plus or minus.

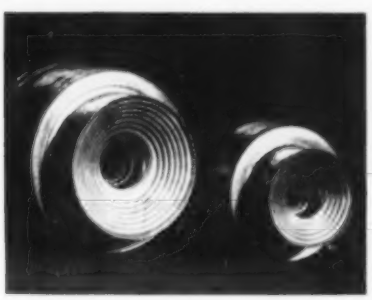
If you'd like a printed discussion of this subject write to our Publications Dept. at Bethlehem, Pa., for the booklet "Distortion of Tool Steels in Heat Treatment."

BETHLEHEM TOOL STEEL ENGINEER SAYS:

Avoid drastic changes of section in tool design

You can expect trouble whenever a tool made of a liquid-quenched steel is designed so that heavy and light sections are adjacent. When such a tool is quenched, the light sections cool rapidly and harden before the adjacent heavy sections. Quenching stresses are set up which often exceed the strength of the steel. Cracking is the result.

Although such tools fail during heat-treatment, poor tool design must take the blame. Troubles of this sort are sometimes avoided by differential hardening or making this type of tool as a two-piece assembly. But if a one-piece construction is necessary, then it's best to use an air-hardening steel.



FOR TOOTHPASTE TUBES

These intricately machined dies are used in shaping the tapered neck and tip of toothpaste tubes which are extruded from round slugs of aluminum. When a punch is driven downward towards the die, the aluminum "biscuit" is trapped between the punch tip and the die and is extruded by the heavy pressure, flowing upwards along the cylindrical punch to form the tube body.

The dies pictured are made from our 67 Chisel tool steel, a chrome-tungsten grade of shock-resisting steel that's ideal for tools and dies requiring plenty of impact strength. Although it is principally a shock type of steel, 67 Chisel is readily carburized whenever extra wear-resistance is needed . . . without sacrificing the advantages of its tough core.

Easy to machine and heat-treat, 67 Chisel is stocked by distributors of Bethlehem tool steel in principal cities.

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4. The parts come out clean and treated to very close tolerances.
5. A large pay load with low ammonia and power consumption saves us money.
6. This furnace stands up under continuous use.
7. Control is easy, giving us exacting case depths in each heat and uniformity from heat to heat."

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Heat Treating Furnaces... Electric Exclusively

Dry Type Transformers *Constant Current Regulators*

Productivity of Die Casting Industry

(Continued from p. 138)

pressure die casting. Different techniques are employed in the two countries for gravity die casting (permanent-mold casting) but the team believed that British methods are more advanced. Labor relations appeared good; the status of the American foreman was particularly noted. Workers realize that profits are essential for a firm to exist and for better wages and conditions to be possible, and agree that monetary risk should receive some reward. In America there appeared to be more cooperation between manufacturer and customer; industry is also willing to try new methods and take risks commensurate with the rewards of success.

Another item noted in the report is the wide use of suggestion and incentive schemes. Neither management nor unions tolerate inefficient workers; they are downgraded or discharged. The maximum utilization of plant and labor is a general objective and double day-shift working almost universal.

Included in the report are the recommendations for British action put forward by the team, such as more detailed planning, limitation of the number of designs, a clearer definition of responsibility, a wider use of unit and nest dies, improvement of work flow, greater use of pallets and mechanical handling, and more semi-automatic machines.

Sigma Phase in Heat Resisting Steels*

In an exhaustive study of the occurrence of sigma phase in 25-20 Cr-Ni steels, the influence of the following factors was explored:

1. Prior heat treatment at 1925, 2100 and 2280°F. (1050, 1150, and 1250°C.) before exposure at lower annealing temperatures.

2. Annealing temperatures in 90° steps between 1200 and 1750°F. (650 and 950°C.).

(*Continued on p.* 141)

*Digest of "Sigma-Phase Embrittlement in 25Cr-20Ni Heat Resisting Steels," by J. I. Morley and H. W. Kirby; *Journal* of the Iron and Steel Institute, Vol. 172, October 1952, p. 129-142.

Sigma Phase in Heat Resisting Steels

(Continued from p. 140)

3. Exposure times of 200 to 8000 hr. at these annealing temperatures.

4. Effect of grain size upon the rate of sigma formation and its distribution.

5. Effect of 5 to 40% reduction by cold work on rate of precipitation.

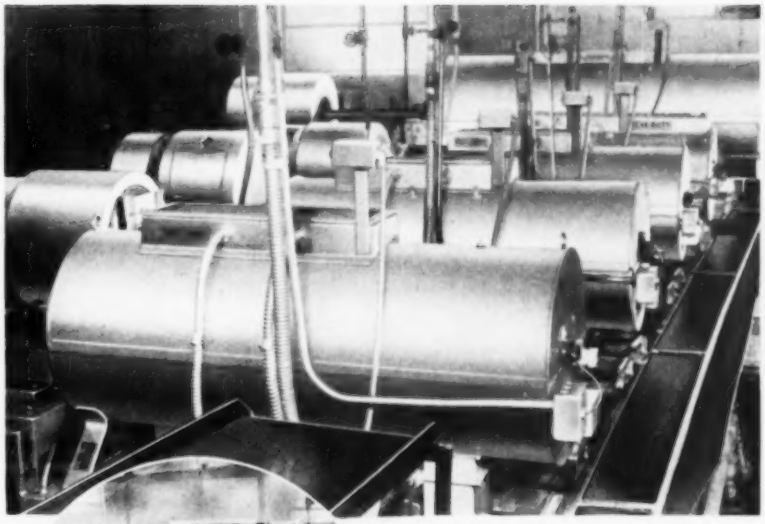
6. Effect of varying the amount of carbon, chromium, nickel, nitrogen, silicon, columbium and titanium in the alloy.

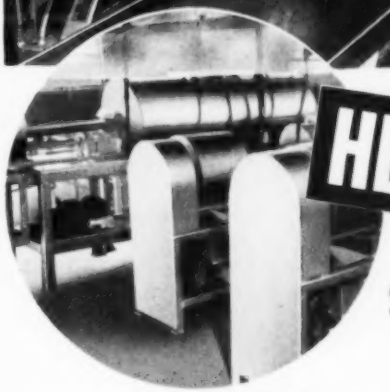
Actual composition of the sigma phase was determined, and mechanical properties such as tensile strength and ductility are given for the various structures developed.

All of the six factors were found to be related to the precipitation of sigma phase; some were accelerators while others retarded the rate and amount of precipitation. As a result, the whole phenomenon becomes quite complicated because of the interdependent influence of the several factors which are always acting in any given composition of this alloy. By a series of tedious and painstaking experiments the authors were able to arrive at definite conclusions as to the effect of the different variables and to determine the effect of varying amounts of sigma phase on the degree of embrittlement. This work was done in the Brown-Firth Research Laboratories.

A commercial alloy containing 0.12% C, 1.46% Si, 21.00% Ni, and 24 to 25% Cr was heated to 1925, 2100 and 2280°F. for 1 hr., air cooled, and then subsequently heated to 1472°F. (800°C.) for periods of 200 to 8000 hr. The 1472°F. anneal was previously found to be the most favorable reheating temperature for rapid and complete precipitation of sigma phase. The specimens heated to 1925°F. had a grain size of A.S.T.M. 7 to 8 and exhibited the most rapid rate of precipitation; in this condition the sigma phase appeared almost entirely as massive particles in the grain boundaries, and the loss of toughness was at a minimum. The 2100°F. heat treatment developed an austenitic grain size of 2 to 4 and this not only caused the rate of precipitation to be much slower (because of longer diffusion paths), but also large amounts of

(Continued on p. 142)





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are saving MONEY...TIME...MATERIAL...

Oregon Saw Chain Corporation, the world's largest producer of top quality saw chain, uses five Hevi Duty Shaker Hearth Furnaces to harden saw teeth. They say, "We have solved a heat treating problem and have paid for the furnaces from the savings."

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The low cost, economical operation of the continuous production type Shaker Hearth Furnace has cut heat treating costs in half. Little maintenance means additional savings.

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Now one man treats more than a ton of small parts every eight hours. Less handling of the parts is required with a steady flow to the production lines.

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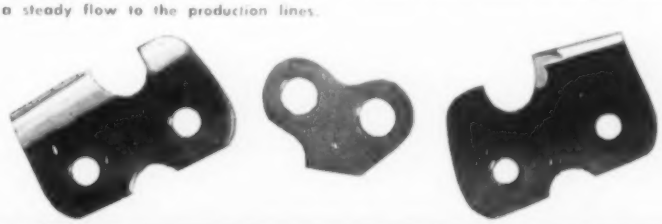
The Hevi Duty Shaker Hearth Furnace treats each part individually. They pass through the furnace in a natural gas atmosphere and fall directly into the quench. This method hardens the saw teeth to 63-65 Rockwell with no rejects due to distortion and scale.

For more information about this modern production tool, write for Bulletin 850.



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Sigma Phase in Heat Resisting Steels

(Continued from p. 141)

the precipitated phase occurred in an acicular form in crystal planes. The 2280°F. heat treatment (grain size No. 1) further retarded the rate of precipitation and increased the amount of acicular precipitate in the crystal planes.

The grain-boundary precipitate tended to appear in the region where three grain boundaries were tangent, and massive sigma-phase particles grew by coalescence at these points after long exposures (1000 to 8000 hr.). In this situation the sigma phase was concentrated locally and formed no complete film surrounding the individual austenite grains.

The amount of sigma phase precipitated at 1472°F. varied from 6% after 200 hr. to as high as 25% after 8000 hr. The rate of precipitation varied with the grain size and exposure temperature. At 1472°F. precipitation was virtually complete after 1000 hr. from a grain size of 8 but required 8000 hr. when the grain size was 1 to 2.

The elongation, reduction of area and Izod impact values were profoundly affected by the distribution of the sigma phase in the structure. The fine-grained specimens, with the precipitate localized in the grain boundaries, were much tougher than the coarse-grained samples which had most of the precipitate inside of the grains in an acicular form on the crystal planes.

The structures discussed above are illustrated by 27 excellent photomicrographs. The carbide and sigma precipitates are clearly shown and there was no evidence of ferrite in any of the samples of this fully austenitic steel. X-ray examination confirmed this. The rates of sigma-phase formation as influenced by grain size, composition, prior heat treatment, exposure time and temperature are shown in a series of graphs and 11 tables.

The chromium carbide precipitate which precedes the sigma phase also concentrates in the grain boundaries, and the sigma phase seems to originate from the carbides. Longer periods of heating at 1472°F. show increasing size and amount of sigma phase at the grain boundary with

(Continued on p. 144)

How LINDE SERVICE* REDUCES THE COST OF OXYGEN

Surface scale and cracks must be removed from steel slabs and billets before they are rolled. Years ago that was a serious bottleneck in steel production.

In 1930 LINDE started to break this bottleneck with the introduction of oxygen scarfing. By 1945 the cost of scarfing had been reduced by LINDE-developed improvements to a fraction of former costs.

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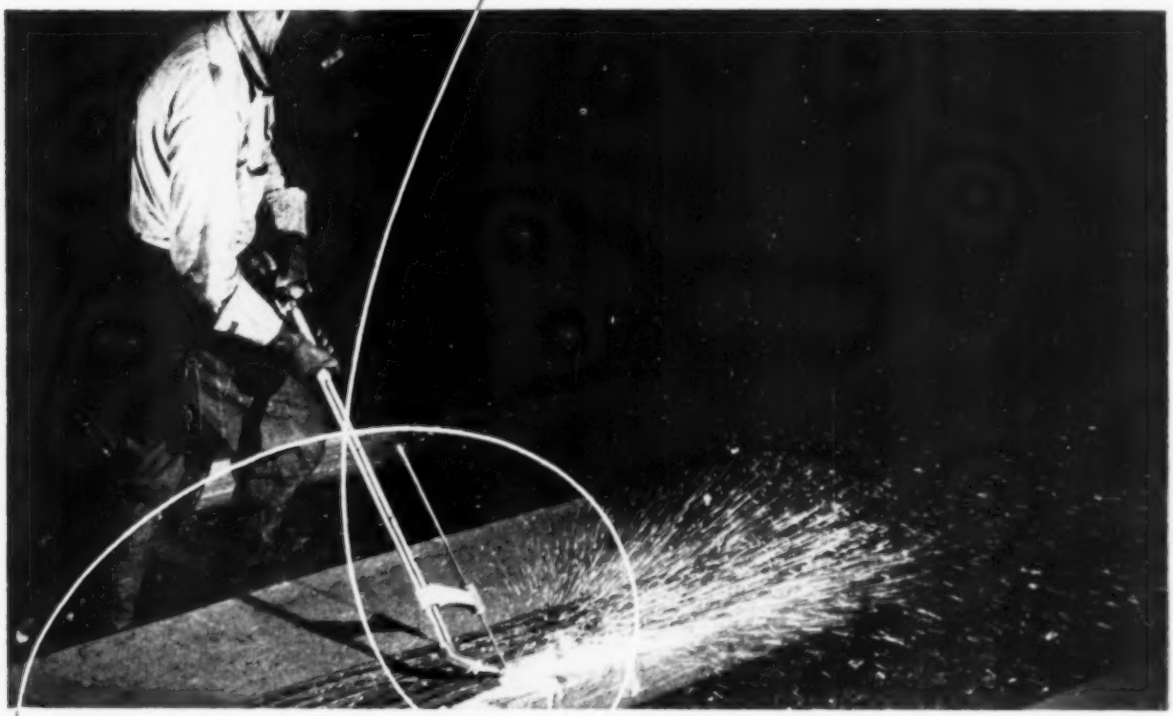

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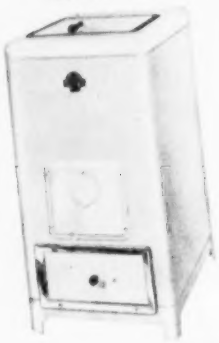

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Sigma Phase in Heat Resisting Steels

(Continued from p. 142)

decreasing amounts of carbides. The authors presume that the carbides dissolve when sigma first appears because the surrounding austenite becomes greatly depleted in chromium around the sigma particles due to their high chromium content (42%). It is well known that the solubility of carbon in austenite increases as chromium decreases.

To study the composition of the sigma phase a residue was extracted by means of an anodic treatment in a solution of potassium iodide and citric acid. The composition of the residue was 0.37% C, 2.67% Si, 0.63% Mn, 9.39% Ni, 45.94% Cr, 39.48% Fe. Assuming all of the carbon present as chromium carbide, the composition of the sigma phase was deduced as 0.0% C, 2.81% Si, 9.96% Ni, 42.18% Cr, 41.86% Fe. A special melt of this composition was made. The resulting ingot was so brittle that it fractured on cooling. Small pieces of this analysis, water quenched from 2100 and 2280°F., consisted of ferrite and carbides. When water quenched from 1920°F. the special alloy consisted of sigma, ferrite and carbide.

The effect of cold working the specimens on the rate and degree of sigma phase formation was studied by stretching samples 5, 10, 20 and 40% and then reheating to 1290 to 1560°F. for periods of 24 to 8000 hr. The results fully confirmed the accelerating effect of initial cold work in promoting sigma-phase formation. As a result this method was used to explore the effect of chemical composition on occurrence of sigma phase.

A table summarizes the influence of carbon, nitrogen, silicon, titanium, and columbium on the 25-20 Cr-Ni matrix, and also includes the results obtained when the ratio of chromium to nickel is varied. In brief, increases in chromium, silicon and titanium increased the tendency for sigma occurrence while increases in nickel, carbon and nitrogen depressed it. The constituent can be virtually eliminated in an alloy containing less than 1% Si, 26% Ni, 23% Cr and 0.15% carbon at all temperatures studied.

E. C. Wright

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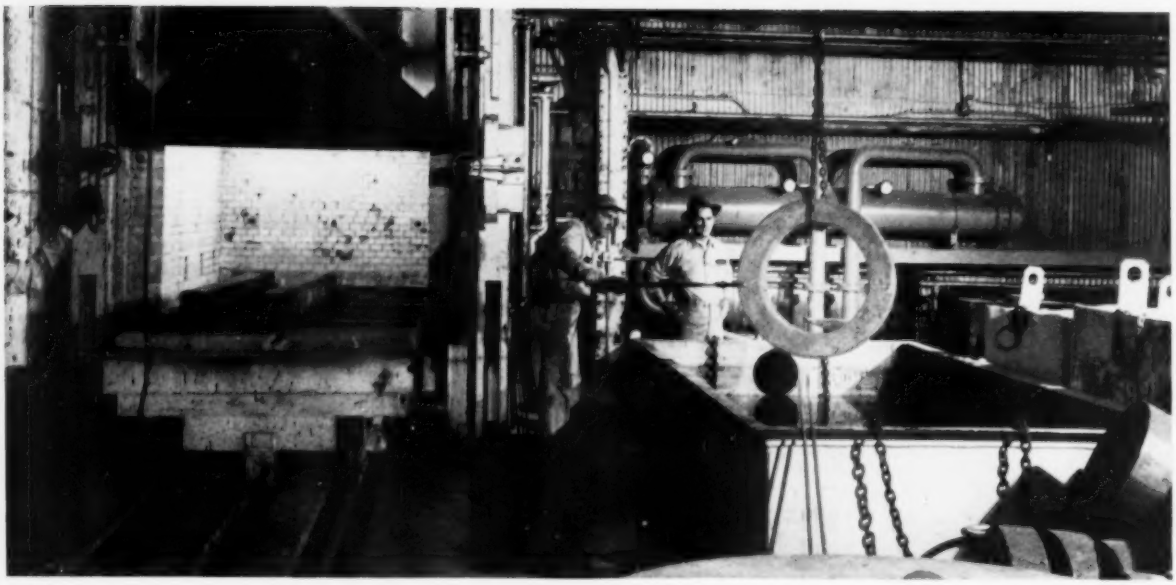

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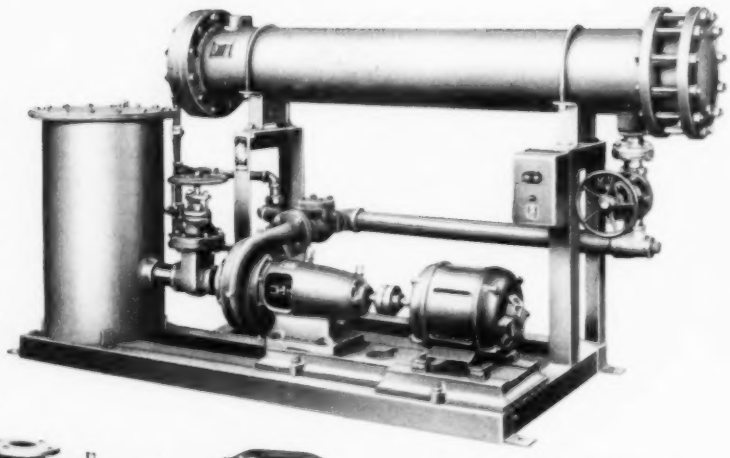

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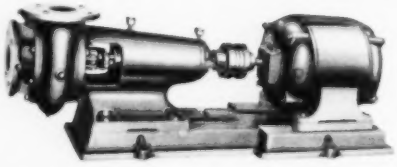

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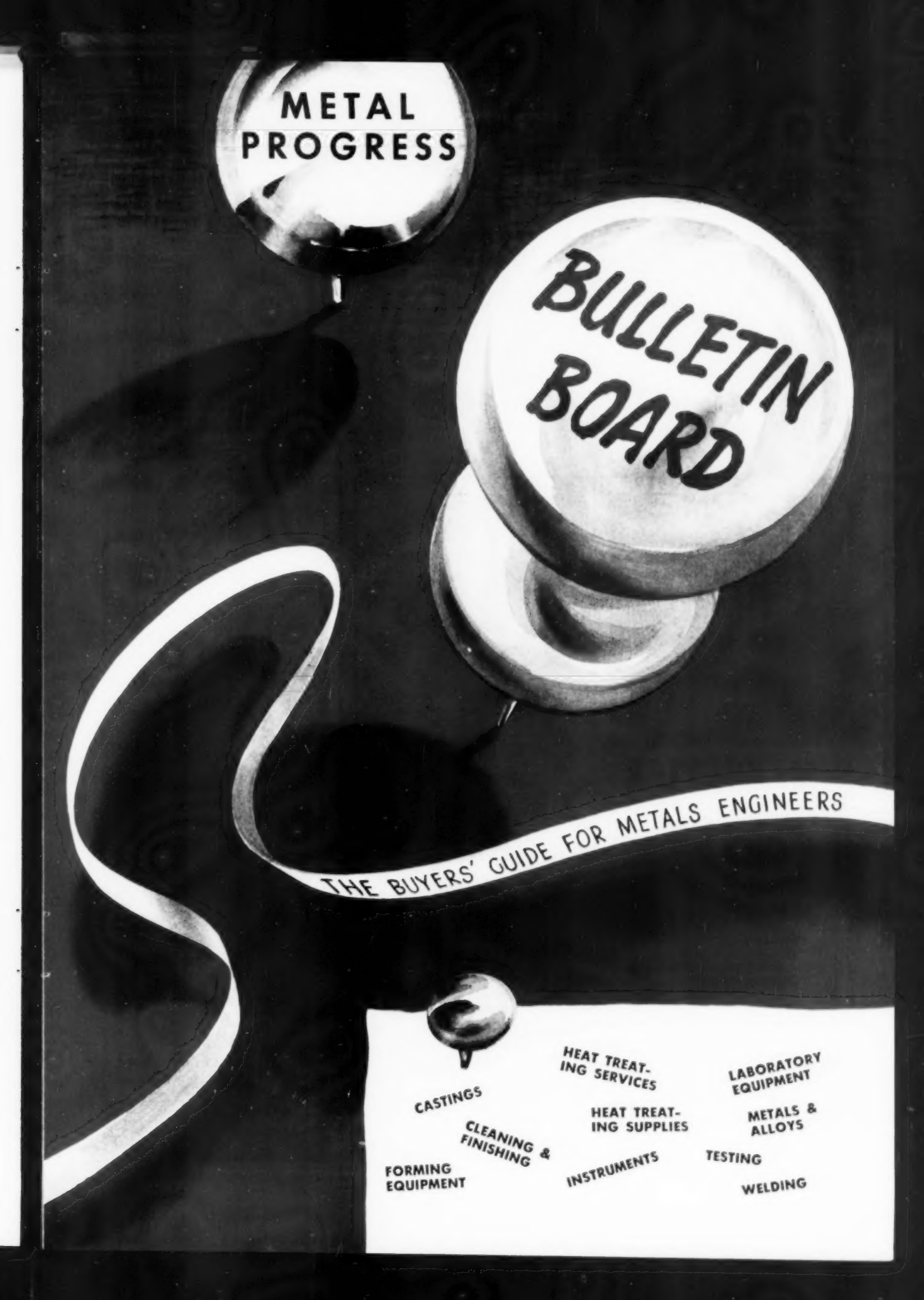
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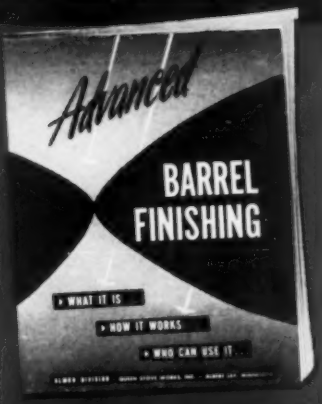

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ALBERT LEA, MINNESOTA

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Write to Abrasive Wheel Department

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If you're working on the production cost angle in metal-working plants or foundries, consider the 20th Century triangle . . . abrasive toughness, economy, longer wear and highly uniform quality.

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- Perfect Uniformity
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for all industrial requirements

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of any size and shape —
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WIRE PRODUCTS Jelliff SINCE - 1880

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DEGREASING SOLVENTS

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CIRCO-SOLV (Trichlorethylene)

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Totally inert to all acids at any concentration except hydrofluoric

Sizes: 1000 to 10,000 Watts

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BARNABY MFG. CO. of Bridgeport, Conn., reports: "Our close proximity to salt water has given us problems in rust prevention for many years. We have experimented with many black oxide finishes but none has proven as successful, safe, and inexpensive as DU-LITE—our tools have better sales appeal—our volume has been on the increase ever since we started using this modern, progressive oxide finish."

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Or send us samples of parts and we will process them for your approval.

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Send information on metal finishing products. . ☐
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Du-Lite
METAL FINISHING SPECIALISTS

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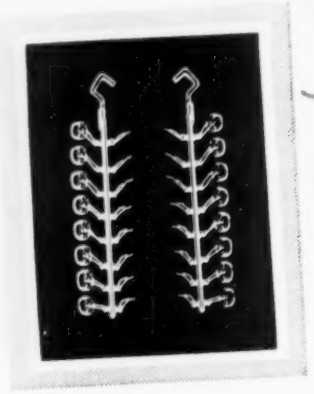

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Upton

. . . . OFFERS

the most advanced Salt Bath **Furnaces**

FOR . . . .

BATCH TYPE WORK

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Phone: Diamond 1-2520

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. . . for Blackening

★ Single or Double Bath Process to meet Any Requirement
★ Faster, more Uniform Blackening
★ Quality Control Formula gives Efficiency of Production
★ Uniformity of Blackening Guarantees Economy

Send for **FREE** Literature on Swift **BLACK** and Cleaning Compounds **TODAY!**

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Free washing!

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Agitator

The economical efficient agitator for

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A high-speed marine-type propeller, located at base of bend, produces strong agitation of mix, upward and horizontally out of bend.

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HEAT TREATING FURNACES

for Every Heat Treating Process

★ CONTROLLED ATMOSPHERES

★ DIRECT FIRED

★ CIRC-AIR DRAW FURNACES

★ CIRC-AIR NICARB (CARBONITRIDING)

Specially Engineered for Your Particular Needs

GAS • OIL • ELECTRIC

INDUSTRIAL HEATING EQUIPMENT COMPANY

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Manufacturers of Industrial Furnaces Since 1927

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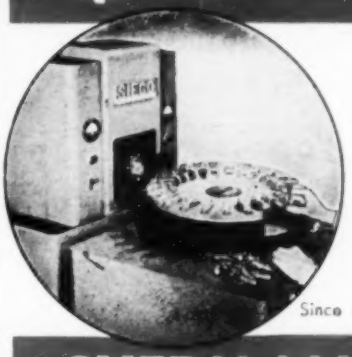

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Fast • Powerful • Reliable

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Serving the

HEAT TREATING INDUSTRY

Since 1930

- Complete Service on Control Equipment
- Thermocouples
- Protection Tubes
- Charts and Lead Wire

THE CLEVELAND ELECTRIC LABORATORIES COMPANY

1988 E. 66 St.

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GAS, OIL AND ELECTRIC
BATCH • CONTINUOUS

ATMOSPHERIC - RECIRCULATING - PUSHER — ROTARY HEARTH — CONVEYOR — RADIANT TUBE - POT CAR-BOTTOM - ALUMINUM REVERBS.

"Tailored by Dempsey"

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HEAT AND CORROSION *Alloys*

Fahrite is used for: Rails • Trays • Carburizing Boxes • Retorts • Chain Solution Pots • Rollers • Muffles • Radiant Tubes • many other products

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THE OHIO STEEL FOUNDRY CO.

SPRINGFIELD, OHIO — Plants at Lima and Springfield, Ohio

ENGINEERS FOUNDERS FABRICATORS METALLURGISTS

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LET'S PUT OUR HEADS TOGETHER---

TO GET THE HEAT TREATING CONTAINERS YOU WANT!

Tell Stanwood Engineers your particular problem—type of parts you are heat treating—furnace capacity—cycle, etc. With our broad experience and production facilities we can supply baskets, trays, fixtures, carburizing boxes, retorts or furnace parts to exactly meet your needs—economically too! Send for literature.

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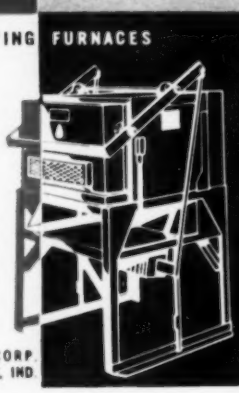
Expand Your Plant Potential

WITH Cooley ELECTRIC HEAT TREATING FURNACES

fast . . . inexpensive way to expand your plant facilities. Choose from 27 Models.

For Instance:

1. You save time and money by keeping heat treat jobs for small parts in plant.
2. It's easy to establish a new department at small cost in proportion to benefits which result.
3. Cooley heat treat furnaces pay for themselves through savings in time and subcontracting costs.
4. Heat treat operations are easily performed with Cooley designed furnaces.



Write now for Catalog giving complete details.

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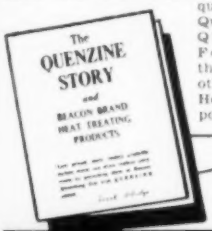
***the* QUENZINE STORY**

Low priced, more readily available carbon steels can often replace alloy steels when quenched in Beacon Quenching Oils with QUENZINE added. For information on this new additive and other Beacon Brand Heat Treating Compounds write to . . .



KELCO

ALDRIDGE INDUSTRIAL OILS, Inc.

3401 W. 140th St., Cleveland 11, Ohio

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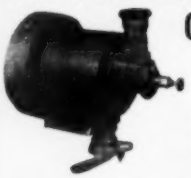
EXPLOSION COMBINATION GAS and OIL BURNER



for HEAT TREAT FORGING MELTING

Our burners afford fuel savings, complete combustion (11⅓% CO_2 Orsat), controlled atmosphere, instant lighting, complete heat ranges. Simple installation and control. Rapid conversion from gas to oil. Also patented refractories in special shapes.

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INDUSTRIAL FUEL BURNING EQUIPMENT..

Designed **FOR YOUR SPECIFIC REQUIREMENTS**

- Motor-Mix Burners
- Model DA Mixers
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- 35 years experience designing and manufacturing Salt Bath Furnaces.
- Originators and pioneers of ELECTRODE FURNACES including these patented features:
  1. Water Cooled Electrodes
  2. Starter Coil
- Salts for all heat treating applications (300 to 2300 F.°) supplied by the CROWN CHEMICAL DIV.

THE BELLIS CO.
BRANFORD, CONN.

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Instruments and controllers for heat treating furnaces

A complete summary of Hays products applicable to processes such as annealing, brazing and calorizing. Scope includes various methods of firing (underfired, overfired, sidefired), fuel burned (gas, coal, oil), and type of furnace (continuous, rotary hearth, slab heating, etc.).

Hays complete line of draft gages, flow gages and meters (for high and low pressure gases and liquids), portable gas analyzers and automatic CO_2 recorders are covered.

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THE HAYS CORPORATION
Michigan City 24, Indiana

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the

METAL SHOW

Cleveland

October 19 to 23

1953

RICHARDS PYROMETER SUPPLIES

Control Temperatures More Closely
Reduce Cost — Save Time

Catalog No. 5 shows you how! Get your free copy today!

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- Protection Tubes
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Low prices for top quality
Prompt shipment from stock

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Spotlighting
DETROIT'S *BETTER*
HEAT TREATER

OFFERING FACILITIES FOR:

1. **ALUMINUM**-CAP. 500,000# PER MO.
2. **MINUTE PARTS** TO 2-TON DIES
3. **BRIGHT HARDENING** OF STAINLESS STEEL

ALL TYPES OF HEAT TREATING CAN BE DONE BETTER BY

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Phone TAshmoo 5-0600

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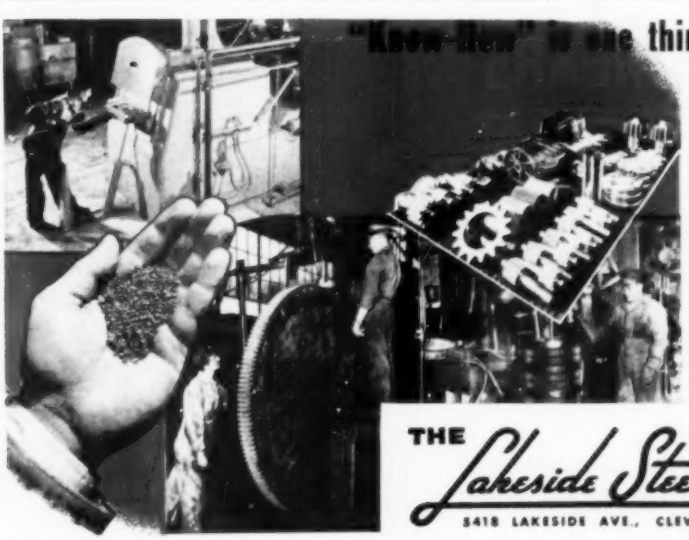

"Know-How" is one thing . . . DOING IT BETTER is what counts!

Whether it's the treating of your rough forgings, castings and bar stock, or your finish-machined parts, you can depend on Lakeside to do it better. From the unbiased, scientific recommendations of your Lakeside metallurgists; through the perfected, fully mechanized, electronically-controlled processes to instrumented, precision testing; Science directs every step. No chance for guesswork, or human error. Only with the finest, modern facilities can you be assured of highest steel treating quality.

THE *Lakeside Steel Improvement Co.*
5418 LAKESIDE AVE., CLEVELAND 14, OHIO HENDERSON 1-9100

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THE STORY OF MALCOMIZING

(for surface hardening stainless steels)

what it is . . . what it does . . how it works . . how you can use it.

Write today for your copy of this 24-page booklet. Specific subjects discussed include . . . pretreating the steels . . . selective Malcomizing . . . case depth . . . wear resistance . . . corrosion resistance . . . . passivation of Malcomized steels.

A special "case history" section shows how nationally known manufacturers are specifying Malcomizing for the surface hardening of stainless steels.

Lindberg Steel Treating Co., covering industrial America from coast to coast, with plants in Rochester, Chicago, St. Louis and Los Angeles, is now licensed to Malcomize for its customers. For particulars call your nearest Lindberg plant.

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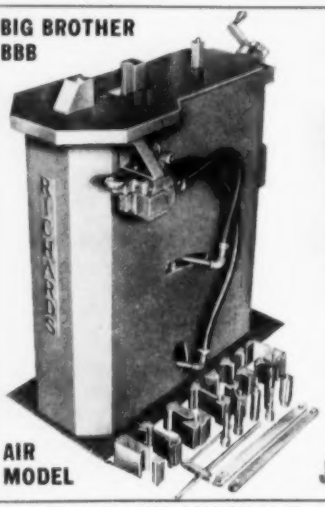
BBB



AIR
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Multiform

Illustrated above are a few of the many forms that can be produced efficiently on the Multiform Bender, using the standard tooling.

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BENDERS-CUTTERS 20 MODELS

FOR BENDING ALL KINDS OF MATERIALS up to ¼" x 4"

GREAT
SAVINGS

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Also build
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Radically Different

Steelweld metal-cutting shears are entirely new with advantages never before possible. Revolutionary pivoted-blade travels in circular path and overcomes handicaps of ordinary guillotine-type shears. No slides or guides to wear and cause inaccuracies. Many other important features. Complete line machines for shearing metal up to 20 feet long or in thicknesses to 1-1/4 inch.

FEATURES GALORE

1. All-welded solid one-piece frame.
2. Electric foot control.
3. Fast Micro-Set Knife Adjustment.
4. Deep throat for wide slitting.
5. Lift-up Back Gauge.

Straight Accurate Cuts

Not only are these machines easier to operate but their design assures smooth straight cuts to hair-line accuracy for years of operation. Their construction is extra heavy, and all modern features are incorporated to provide for ease of operation, minimum maintenance and long life.

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THE CLEVELAND CRANE & ENGINEERING CO.

5939 East 282nd Street • Wickliffe, Ohio

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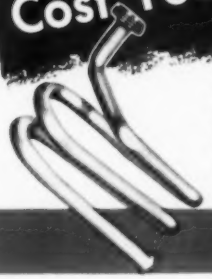
How Much Does CORROSION Cost Your Plant?

Specify **ILLIUM** Construction to Stop Corrosion Losses PERMANENTLY



This is Illium welded tubing. Easily bent and flared to exact tolerances, it retains a bright finish in service.

If your product or plant must handle sulfuric . . . nitric . . . phosphoric . . . mixed acids . . . or acid-salt solutions, you can profit by using Illium.

More than 30 years of use in critical processing operations have proved Illium unsurpassed in handling these highly corrosive acids—both liquids and gases—at virtually all concentrations and temperatures. In addition, it also serves to resist erosion and heat equally well.

Ideal for use in the drug, dairy, chemical and food industries because it lends itself so perfectly to sanitary construction. Other outstanding uses have been found in petroleum processing, ordnance work, and many marine applications.

Available in castings up to 575 lbs., Illium is easily machined and welded. Samples for testing and investigation will be sent upon request.

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THE ILLIUM CORPORATION, FREEPORT, ILLINOIS

Makers of Special Alloys and Quality Castings for Industry

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BOLTS & CAP SCREWS
SOCKET, SET & CAP
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ARDCOR *Engineered*

TUBING ROLLS

AND

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To Your Specifications or Ardcor Design
— for all makes of machines

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RIGIDIZED METALS CORPORATION

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U. S. & Foreign Patents

50 Warehouses & Sales Representatives in All Principal Cities

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USE OUR

HOEGANAES SPONGE IRON POWDER

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BRONZES • ALUMINUM

COPPERWELD • SILVER PLATED WIRES

OTHER NON-FERROUS

ROUND **WIRE** FLAT

for

* SPRINGS
* FORMS
* ELECTRONICS
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INCORPORATED

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your comprehensive independent source of magnesium alloy

Tubes • Rods • Shapes • Bars

Hollow Extrusions • Plate • Strip

• Pipe • Wire • Welded and Riveted structures and assemblies

WHITELIGHT MAGNESIUM

WHITE METAL ROLLING & STAMPING CORP.

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MANUFACTURERS • PROCESSORS OF STAINLESS AND HEAT RESISTANT ARC WELDING ELECTRODES

★ ★

AUTOMATIC WELDING

ALL ANALYSES—COATED, STRAIGHTENED AND CUT, OR COILED

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NORTH RANDALL (CLEVELAND 22), OHIO

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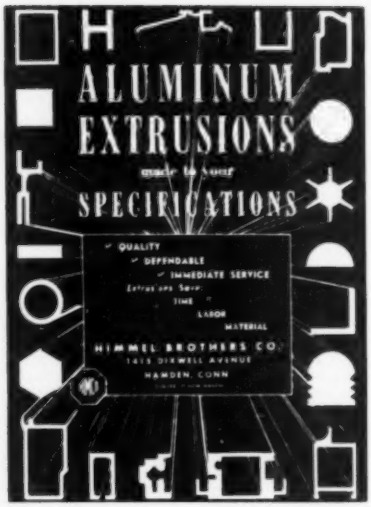

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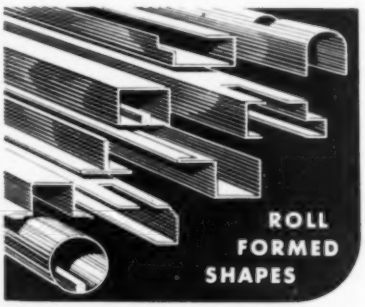

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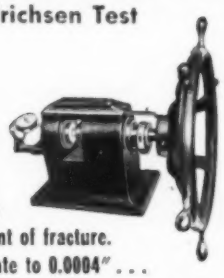

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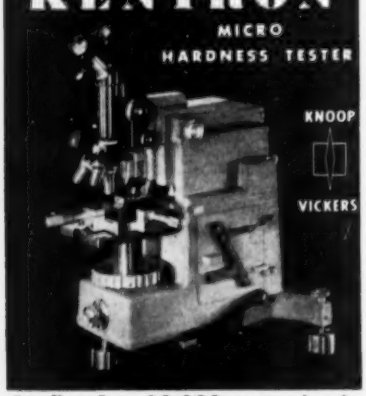

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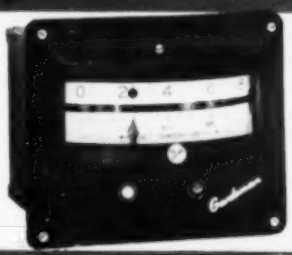

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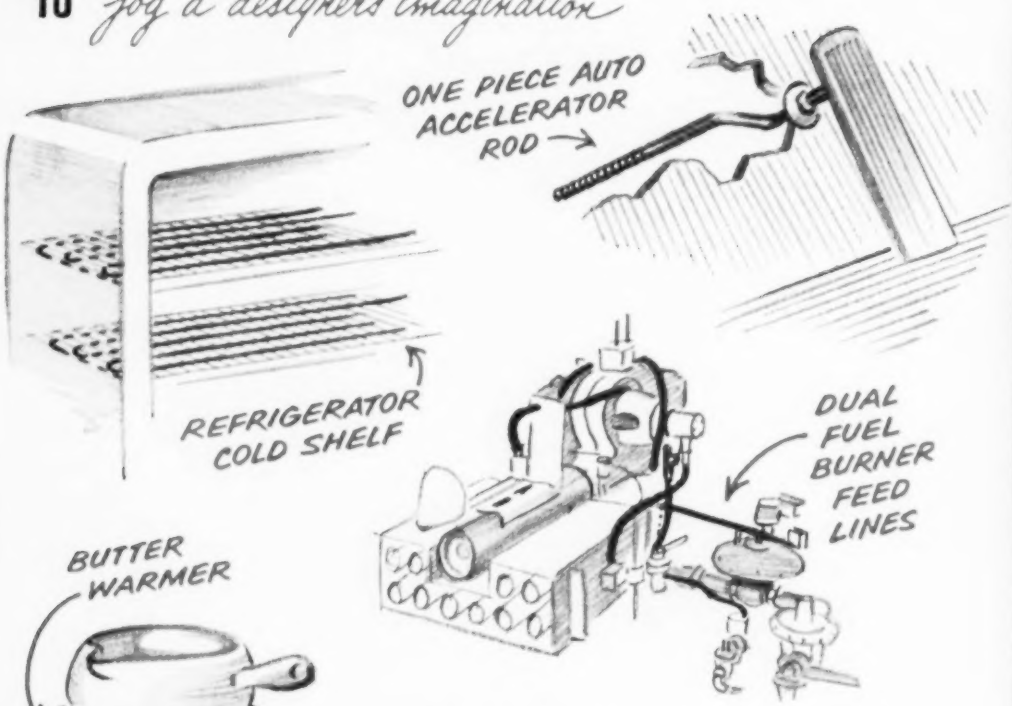

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By JAMES H. MOORE
Director, Metallurgical Department
National Research Corp., Cambridge, Mass.
(Now General Manager, Vacuum Metals Corp.)

Development of Commercial Vacuum Furnaces for Melting Metals and Alloys

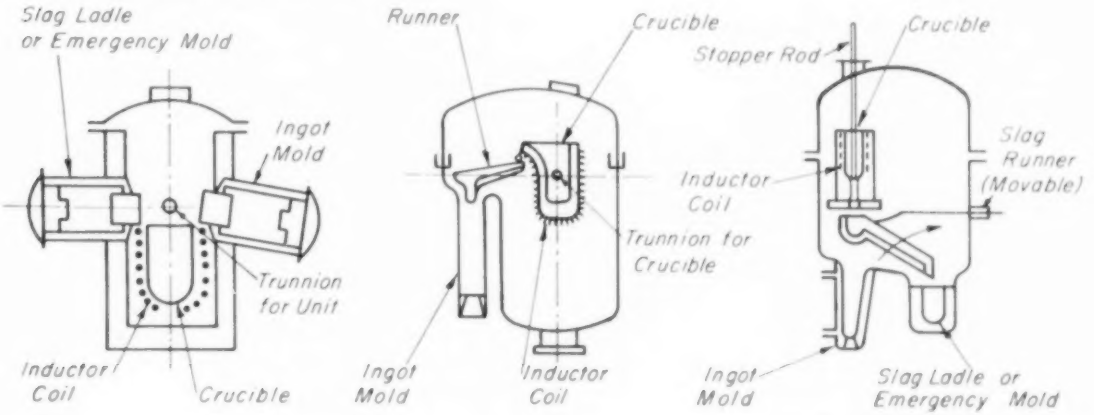
RESEARCH METALLURGISTS recognized at least a half-century ago the usefulness of vacuum melting for the production of small quantities of high-purity, carefully controlled metals and alloys. W. C. Arsem pointed out to the Electrochemical Society in 1906 that vacuum melting would purify metals by volatilizing impurities and by favoring reactions with gaseous products, and that exact compositions could be retained by avoiding oxidation.

The Arsem-type furnace was for many years the standard tool for carrying out all sorts of metallurgical reduction and refining reactions in a vacuum, although it was adapted only to melting and solidification without pouring. Arsem recognized the desirability of being able to cast *in vacuo*, but apparently never worked out the furnace design to permit it.

Prior to World War I, an Arsem furnace which could be evacuated to a pressure equivalent to 0.5 mm. of Hg * by a Guericke mechanical pump, was used by the late T. D. Yensen in his early work with the iron-silicon alloys to make 500 to 600-g. melts. While this could melt with some degree of success, it had disadvantages which led to a departure from the graphite resistor originally used as a heating element. Many early experiments were made with ex-

*1 atmosphere = 760 mm. Hg.

Fig. 1—Sketches of the Three Basic Types of Heraeus Vacuum Melting Furnaces—Tilting Unit, Tilting Crucible for Lip Pouring, Stationary Crucible for Teeming



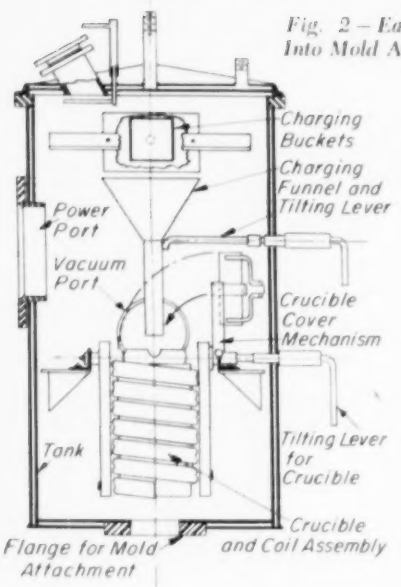
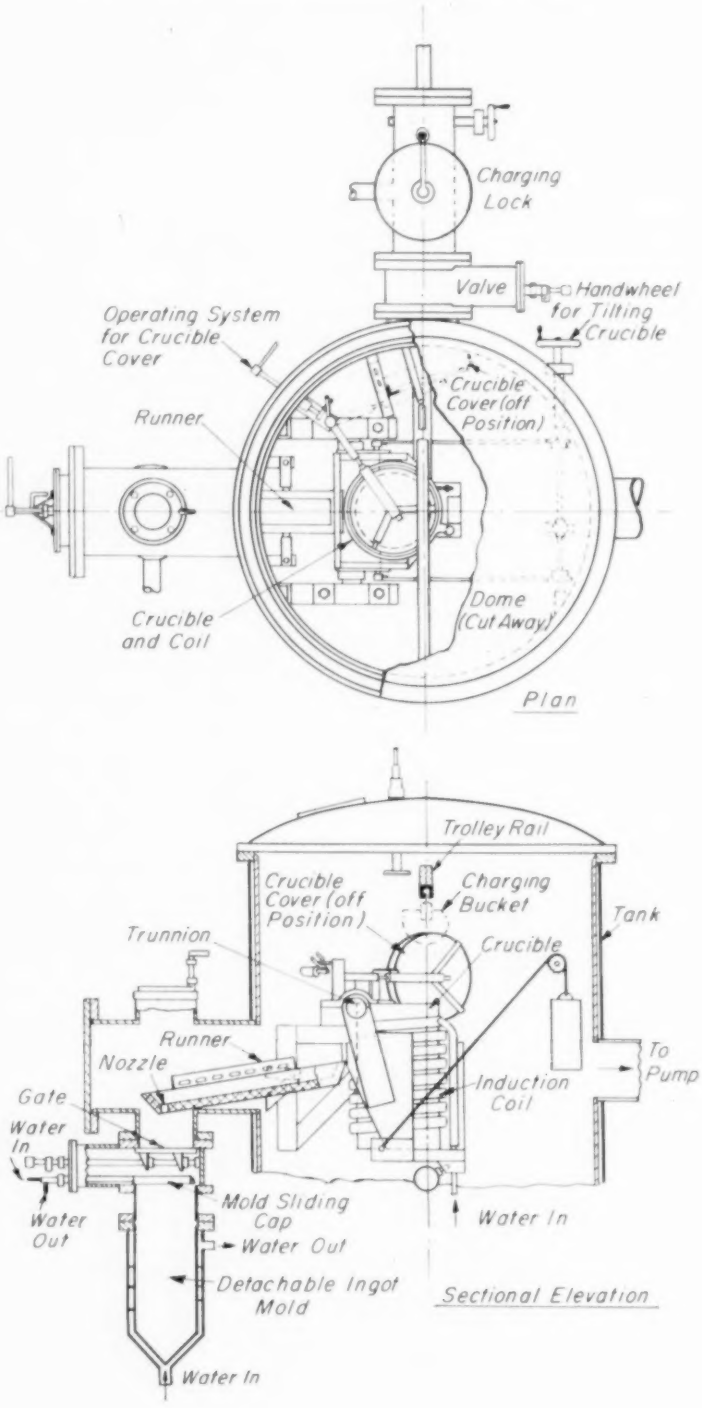


Fig. 2 – Early Unit for Tilt Pouring Into Mold Attached to Bottom of Tank.

Fig. 3–General Assembly of National Research Corp. Unit for Semi-Continuous Melting in Vacuum



ternally heated tube furnaces, but the quartz tubes usually collapsed when the temperature got into the melting range of the metals of most interest. The use of an evacuated quartz tube containing a crucible heated by a co-axial high-frequency induction coil around the tube was one solution to this problem; the walls of the vacuum chamber in this design remained cool. An advanced example of such a device has been described in *Metal Progress* for September 1947 ("Vacuum Melting and Casting of Beryllium", by A. B. Kaufmann and E. Gordon). In this furnace the melting crucible had a stoppered hole in its bottom through which the melt flowed to an ingot mold directly beneath.

Another school of thought led to the bell-jar type of unit in which the induction coil was placed within the vacuum chamber. This design, coming after World War I, was coincident with the beginning of the development of high-vacuum pumps. In the furnace designed by Brace and Ziegler of the Westinghouse staff and described by them in *Transactions*, A.I.M.E., Vol. 78, 1928, p. 544, a pressure of less than a micron of mercury (0.001 mm. or about a millionth of an atmosphere) was said to be attainable with mercury condensation pumps.

While this development of induction heated experimental furnaces was progressing in this country, Wilhelm Rohn began the activity in Germany which led to the first commercial vacuum melting. During World War I, he began experimenting with the preparation of nickel-chromium alloys in vacuum to replace the scarce platinum-base thermocouple alloys. By 1923, the field appeared sufficiently promising to warrant the founding of a new firm, Heraeus Vacuumschmelze, as a subsidiary of W. C. Heraeus, and production units were constructed. The first were heated by low-frequency induction and were made with capacities as high as 8000 lb. These were later discarded in favor of high-frequency induction units. Of the three basic designs of the latter, shown in Fig. 1, all had both the induction coil and the mold or molds in vacuum. The major design difference was in the method of pouring. In the first, the whole tank tilted; in the second, the crucible alone was tilted within the chamber; and in the third, a bottom-tapped crucible was employed. Present operations of Vacuumschmelze A. G. (now part of Siemens-Halske), utilize primarily the first and third types of furnace.

While this German development took the vacuum melting operation out of the laboratories into the plant it did not improve the technique with respect to the pressure range which could be obtained. Mechanical pumps were used, with a blank-off pressure of about 100 microns (0.1 mm. Hg), but the actual furnace operations were in the range of 5 to 10 mm. Hg. In this country, it has been noted that the period between world wars saw the use of the high-vacuum condensation pump to obtain lower pressures in the Brace and Ziegler unit. With the design of the first oil diffusion pump by Burch in 1929, and the subsequent multi-stage types of oil vapor pumps, an improvement in pressure of several orders of magnitude became possible. The demands in World War II for large low-pressure operations in several fields, especially in the separation of uranium isotopes by electromagnetic means, gave considerable impetus to this development. During the war, the metallurgical department of National Research Corp., manufacturers of high-vacuum equipment, also began to devote considerable attention to vacuum melting and casting equipment and processing techniques.

Our first furnaces, capable of melts of 15 to 300 lb., had 10,000-cycle, 200-volt induction coils within metallic tanks. These tanks held bottom-tapped crucibles which discharged into water-cooled copper molds attached to the furnace tank. Tapping was by stopper rod, operated through a seal. A 300-lb. furnace used for melting copper has been described in an article by Stauffer, Fox and DePietro in *Industrial and Engineering Chemistry*, Vol. 40, 1948, p. 820. For producing electronic grade copper and certain nonferrous metals and alloys, equipment of this design is still in use, but it is unsatisfactory for steels, high-temperature alloys and many nonferrous alloys. Difficulties were introduced by failure of refractories —oxide crucibles and stopper rods— caused by softening, erosion and reaction. Tilt-pouring techniques were needed.

The first National Research Corp. unit employing tilt pouring is shown schematically in Fig. 2. A coil assembly which can be up-ended holds a crucible which in turn has a removable cover. A mechanism is provided for making additions consisting of a funnel and several small buckets, remote controlled. At the bottom of the main tank is a mold flange to which can be attached either a water-cooled copper mold, or a mold tank which could hold an ingot mold or a shaped mold. A 10,000-cycle, 200-volt, 30-kw. motor-generator furnished the power. This unit has been successfully used for a wide variety of metals and alloys, at first for 15-lb. and later for 30-lb. melts. Both ingots and precision castings were produced for research purposes.

It became evident from experience with such batch-type melting furnaces up to 100 lb. in size, that semicontinuous operation would be necessary if vacuum melting could be properly exploited on a commercial scale. As techniques for vacuum refining progressed, this new type of unit was formulated.

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(Continued on p. 164)

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Vacuum Furnaces

(Continued from p. 163)

at National Research Corp. is illustrated in Fig. 3. Charging and discharging locks were incorporated so that a melt could be tilt-poured into an ingot mold or a shape mold, the mold chamber locked off, and the crucible reloaded through the charging lock. The latter was designed to handle the widest variety of materials, such as compressed trimmings, electrolytic flake, powder, pellets or massive scrap. Thus, the next meltdown starts in the hot crucible while the preceding ingot is being removed. This not only greatly reduced the furnace cycle by eliminating the long cooling of the hot crucible assembly before opening to recharge, but was also beneficial to the life of refractories.

Reference to Fig. 3 will show the major components of this type of furnace. The crucible is charged by a retractable bucket through the charging lock and valve. Heat for melting is furnished by a 3000-cycle, 400-volt induction coil. The crucible may be poured at the conclusion of the refining cycle into the runner which has a controlled orifice or nozzle over the mold. After pouring, the mold and ingot are locked from the main chamber by the gate just below the pouring nozzle and the ingot may be removed by venting the mold chamber. By the proper design and operation of all locking components one can operate with essentially no effect of charging or discharging on the pressure within the melting chamber.

The operating pressure range of the furnace is from about one micron to one atmosphere, with the usual end point for a low-pressure refining cycle at from one to ten microns. A three-stage pumping system provides high capacity throughout this range of pressures.

Much information about refining techniques has been gained from operating this type of furnace for several years. The evolution of improved commercial equipment has continued. In the plant of Vacuum Metals Corp. (a subsidiary of National Research Corp.), for example, one of the furnaces is capable of producing 1000-lb. ingots of copper alloys and 600-lb. ingots of steels and high-temperature alloys. Others pro-

(Continued on p. 166)

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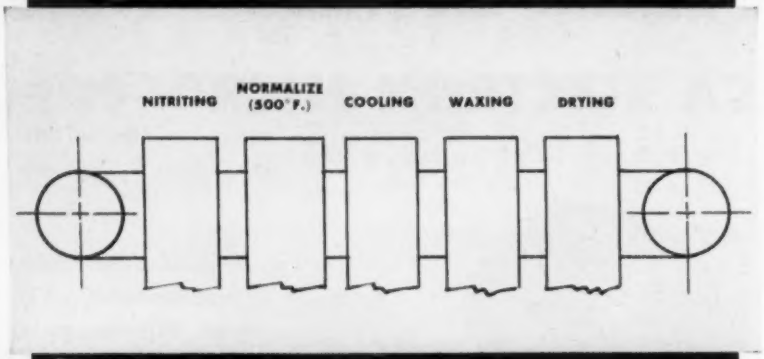

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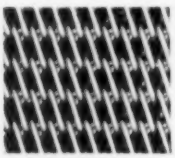

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Vacuum Furnaces

(Continued from p. 164)

duce melts of approximately 50, 100, and 300 lb. for metals other than the light alloys.

Ingots from these furnaces are fabricated into a variety of products for sale to industry. Much of the present output is going into pilot production lots in various applications. A subsequent article will describe the characteristics of some of the improved metals and alloys so manufactured.

Cast Furnace Resistors*

METALLIC HEATING ELEMENTS such as electric resistors are usually manufactured from drawn or rolled wire or strip. Cast elements are rarely used because of the difficulty of casting the small sections, combined with the brittleness of the alloys; their life is unsatisfactory mainly because of porosity which is commercially unavoidable in certain alloys (for example, the 80-20 Ni-Cr) with the present foundry technology. The Russian investigators found that additions of Ca, Mg, Ce, Ba, and Li to alloys (nominally) 80-20 Ni-Cr, 15-30 Cr-Ni (balance Fe), and 25-5 Cr-Al (balance Fe) produced satisfactory cast elements. They show little porosity, have high ohmic resistance, good plastic properties, and improved life in service.

Laboratory melts were made in a basic-lined induction furnace, but in order to find whether the inoculants could be safely added to larger masses, a number of melts were made in a larger basic arc furnace. Metallic calcium was easily absorbed by the first two parent alloys mentioned above. When introduced into the aluminum-containing alloy it produced a considerable flash and caused turbulent (but not dangerous) boiling of the metal in the ladle. Introduction of metallic lithium into the molten metal is very difficult because the formation of LiS from residual sulphur and the evaporation of lithium nitride is accompanied by a strong explosion.

(Continued on p. 168)

*Digest of "Heating Elements for Electric Resistance Furnaces Cast From Inoculated Alloys" (in Russian) by N. S. Kreshtshanovsky and A. D. Sventshansky in *Foundry Production*, 1952, No. 4, p. 6-11.

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Cast Furnace Resistors

(Continued from p. 166)

Additions of barium were easy. Cerium was added as ferrocerium to the Cr-Al-Fe alloy, and as mischmetall (an alloy containing the other rare earths) to the Cr-Ni alloys. Magnesium was used in the form of a Ni-Mg master alloy for the Cr-Ni alloys; but with the third it produced similar effects to lithium as mentioned above.

The effect of the different inoculants on microstructure was fundamentally the same in the ¾ x 16-in. cast specimens as in the 900-lb. ingots. As-cast ordinary 80-20 Ni-Cr shows large columnar crystals in ingots, transcrystallization in small sections, and porosity in both. Addition of calcium or magnesium eliminates the pores entirely, results in very fine-grained small sections, reduces the columnar zone and refines the inner part of the ingots. Cerium up to 0.6% had little effect except for reducing porosity. Lithium (0.2%), in addition to eliminating the pores, also eliminated columnar crystals.

The Cr-Ni-Fe alloy had no porosity but a strongly developed transcrystallization zone. All the inoculating elements except calcium refined the grain and halved the thickness of the columnar zone in the 900-lb. ingots of this analysis. Cerium caused the latter zone to grow until it sometimes reached the center of the ingot.

The effect of calcium and magnesium was the same in the Cr-Al-Fe alloy as in the others; cerium did refine the grain but to a lesser extent.

Addition of 0.75% Ca, 0.3% Mg, 0.6% Ce, 0.2% Li, or 0.5% Ba inhibited entirely grain growth of 80-20 Ni-Cr after 500 hr. at 2300°F. These inoculants are very strong degasifiers. "Vacuum-melted" Cr-Ni-Fe contained 2.7 cc. H_2 per 100 g.; the metal was dense, fine-grained, and columnar crystals were absent. When a similar melt was blown with hydrogen for 10 sec., the residual hydrogen was 16.4 cc. per 100 g., and columnar zone appeared, coupled with extensive micro-porosity, mainly along the grain boundaries. After continued blowing with hydrogen for 30 and 60 sec., the magnitude of these adverse effects increased rapidly, and large pores developed eventually. Ca, Mg, or Li, in the amounts indicated, reduced the hydrogen content to between half and a third of its original value, with a simultaneous retrogression of the phenomena just enumerated.

Alloying with these alkaline or alkali-earth elements improves the life of the heating elements by inhibiting melting at the grain boundaries. Presumably, nonmetallic inclusions of low melting point are fluxed out by these reactive metals.

These small additions also strongly influence the life of the heater elements. After heating at 2300°F. for 250 hr. by passing current through them, the plain Ni-Cr alloy shows extensive fusion of the grain boundaries throughout the entire section; this is absent from the inoculated alloys. However, keeping the ordinary Ni-Cr casting in an independently heated furnace for the same time does not produce the above changes. It is suggested that concentration of inclusions—especially sulphides—at the boundaries reduces the active cross section as far

(Continued on p. 170)

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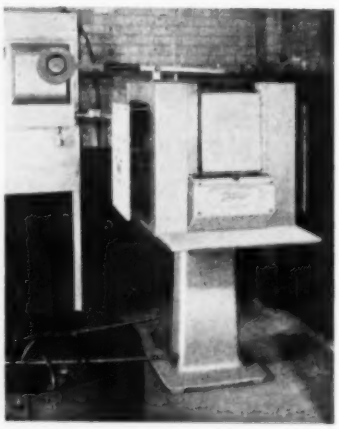

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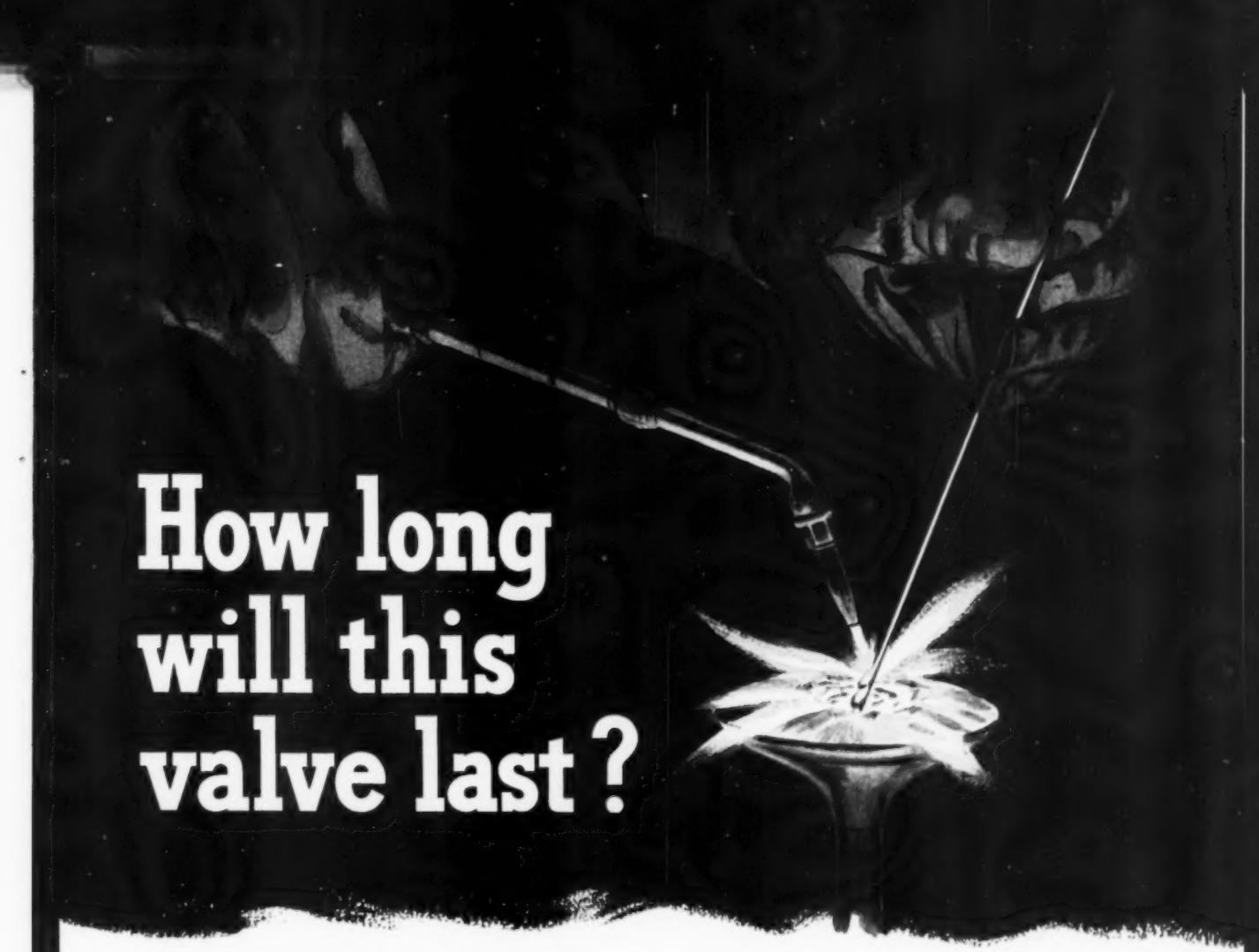

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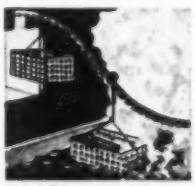

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Cast Furnace Resistors

(Continued from p. 168)

as current conductivity is concerned, thereby increasing the resistivity which leads in turn to localized overheating and fusion. Evolution of free hydrogen and microporosity created thereby at the boundaries aggravates the situation still further. The inoculants not only degasify the liquid alloy but also lock up the sulphur in stable compounds instead of easily melting eutectics. Inoculated alloys are dense and inclusions are dispersed and harmless.

The heating elements must be of simple but rigid design. A Vee cross-section is advocated with 0.08-in. wall thickness, 0.8 in. high, and with a bottom radius of 0.3 in. A single element has the form of reversed U's arranged into a continuous wave with overall length of about 10 in. and height of 6½ in.

The pouring temperatures differ according to composition, but for 80-20 Ni-Cr, 2700 to 2725°F. represents the optimum. Suitable sand molds may be prepared from 70 to 75% sand, 25 to 20% quartz flour, 2.5% linseed oil, and some minium (red lead) and gypsum added with 2.5% water. These were dried for 4 to 5 hr. at 400°F.

Service trials with calcium-treated heater castings yielded very satisfactory results. No deterioration of properties was found after 1100 hr. at 2000°F., 860 hr. at 2200°F., or 235 hr. at 2400°F.

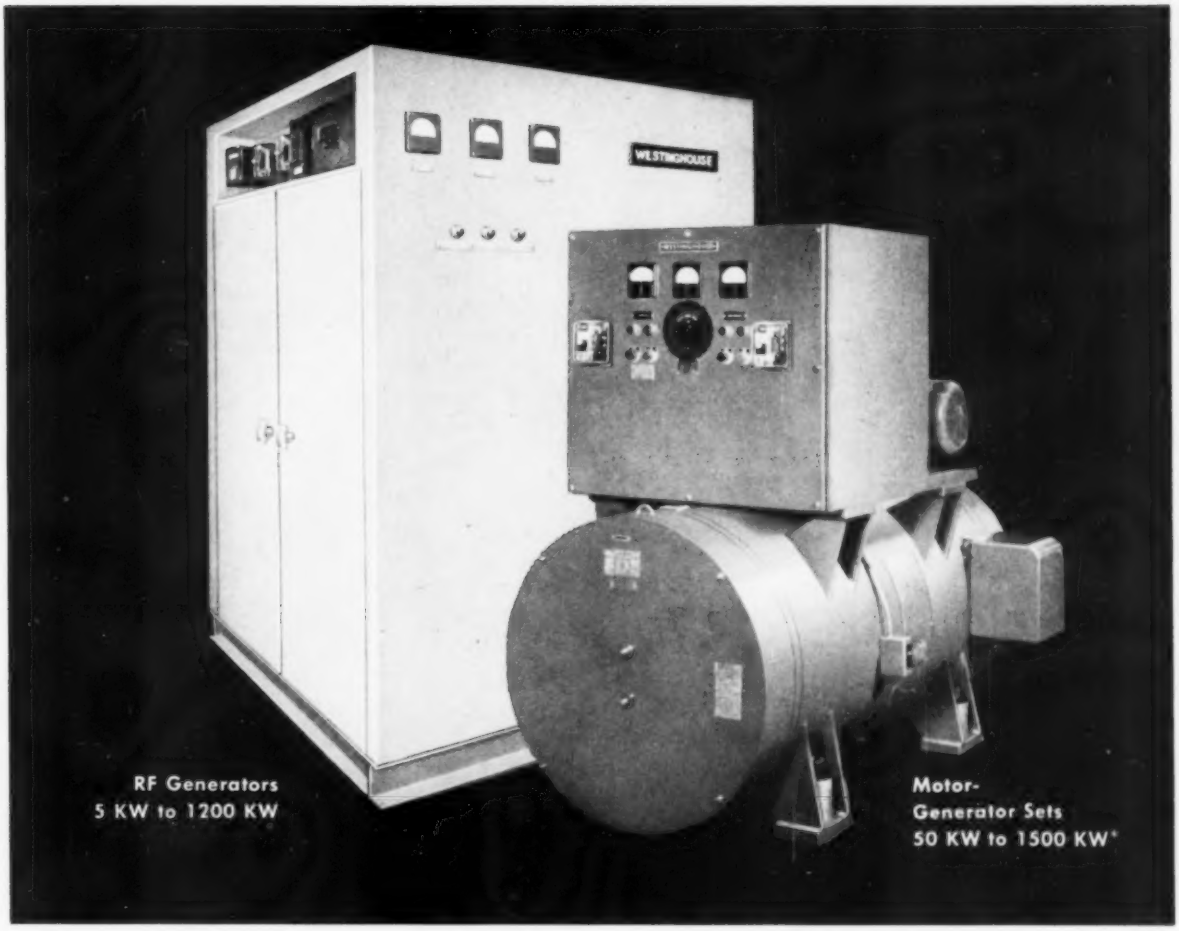
N. H. Polakowski

Process of Bainite Formation*

There are still a few mysteries remaining in the metallurgy of steel, and one of the most fascinating of these shrouds the formation of bainite. Theoretical and experimental work has led to a rather clear understanding of the mechanisms of pearlite and martensite formation. Similar attacks have been made on the bainite problem by numerous investigators, but these have not been particularly successful. For example, it has not been clear whether

(Continued on p. 172)

★Digest of "The Formation of Bainite," by T. Ko and S. A. Cottrell, *Journal* of the Iron and Steel Institute, Vol. 172, November 1952, p. 307.



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Process of Bainite Formation

(Continued from p. 170)

the lattices of bainite and austenite are coherent (as in martensite formation) or are incoherent (as in the austenite-ferrite reaction). Furthermore, as Ko and Cottrell point out, it is not known whether bainite forms by a process of nucleation and growth (as ferrite and carbide do) or instantaneously as does martensite.

Another important question is whether there is any real difference in the mechanism of formation of "upper" and "lower" bainite. Ko and Cottrell have attacked the problem of bainite formation in a unique and illuminating manner, and their results have clarified many of the problems and have led to a rather clear understanding of its formation.

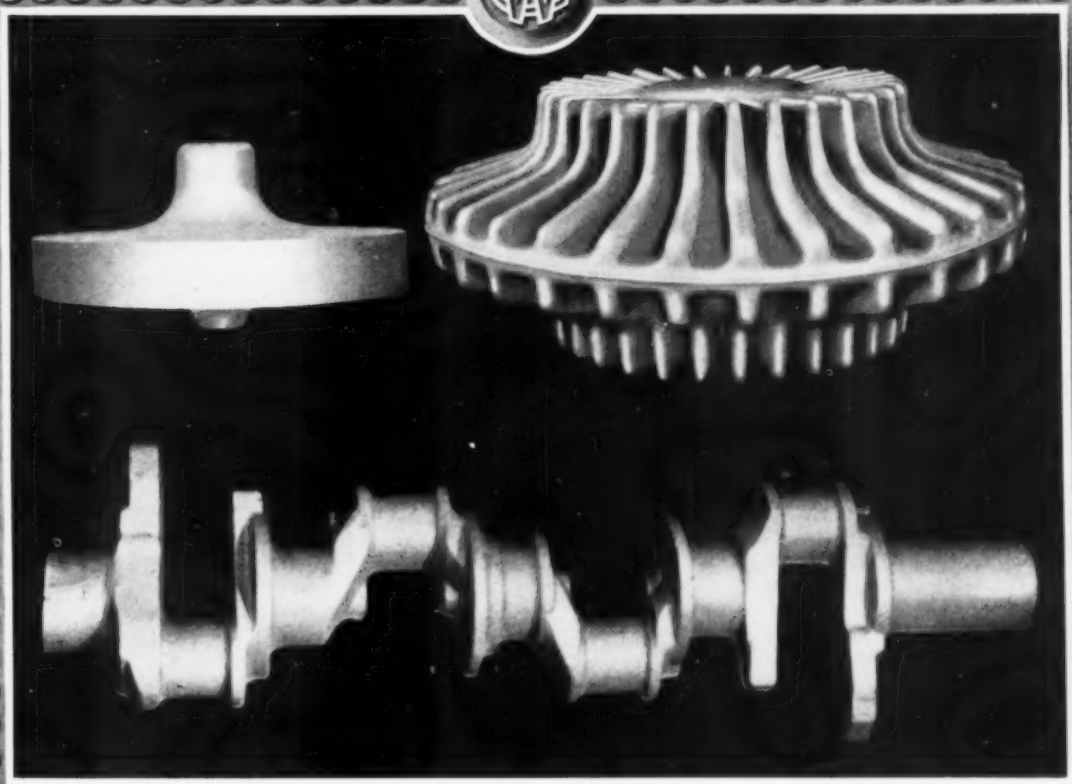
The acicular aggregate of ferrite and carbide particles, called bainite, has been studied extensively since its discovery by Davenport and Bain in the late 1920's. Inasmuch as the transformation from austenite to bainite requires time, it has been thought by many to be a process involving nucleation and growth. Early investigators were handicapped because the light microscopes they used were unable to resolve the fine structure of bainite. This obstacle was eventually surmounted with the aid of the electron microscope which showed that bainite is an acicular structure composed of ferrite containing dispersed particles of carbide.

A number of suggestions have been made concerning the process of bainite formation. Davenport and Bain originally thought that lower bainite forms as martensite which tempers rapidly, so they called it "martensite-troostite." Somewhat later, Bain, Weaver and Portevin concluded independently that bainite forms as supersaturated ferrite which begins immediately to reject carbide particles.

In 1940, Greninger and Troiano suggested that bainite formed as an aggregate rather than as single-phase crystals. A few years later, Hultgren arrived at the same conclusion.

In 1942, Smith and Mehl found that bainite plates in a series of specimens increased in both width and length during the time bainite

(Continued on p. 174)



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Process of Bainite Formation

(Continued from p. 172)

was forming; therefore, they concluded that bainite forms by a process of nucleation and growth. This conclusion had also been reached by Foster and Scheil, who made similar experiments in Europe.

Studies of the habit planes in the austenite which govern the orientation of the bainite revealed that these planes change markedly with the temperature of transformation, being near those for pro-eutectoid ferrite at 450°C. (842°F.) but close to those of martensite at the low temperatures.

Recently, theoretical analyses of bainite formation have been made by Zener and by Fisher. They have attempted to calculate the shape of the isothermal transformation curves for bainite by assuming that bainite forms as supersaturated ferrite free from strain, and by a mechanism similar to martensite formation.

Ko and Cottrell have attempted critical experiments which are meant to resolve the uncertainties which still exist. They used eight steels ranging in carbon from 0.32 to 1.08%, and containing various amounts of nickel, manganese, chromium and molybdenum. Specimens of these were polished, sealed in evacuated silica tubes, austenitized and then quenched to the isothermal transformation temperature. At different intervals of time, the bainite reaction was interrupted by heating the specimen to a temperature at which the remaining austenite decomposed rapidly to pearlite. Thereafter the specimen was cooled and examined under the microscope. Additional experiments were also performed with a hot-stage microscope so that a continuous record of the bainite formation could be obtained. Their results are illustrated with 18 micros.

The basic feature studied by Ko and Cottrell was the relief of the surface of the transformed specimens. A martensitic type of reaction, in which there is homogeneous distortion and coherency of the lattices, causes a relief effect on the surface; the formation of pearlite (a nucleation and growth process) does not. They found that bainite forms by coherent growth from

(Continued on p. 176)

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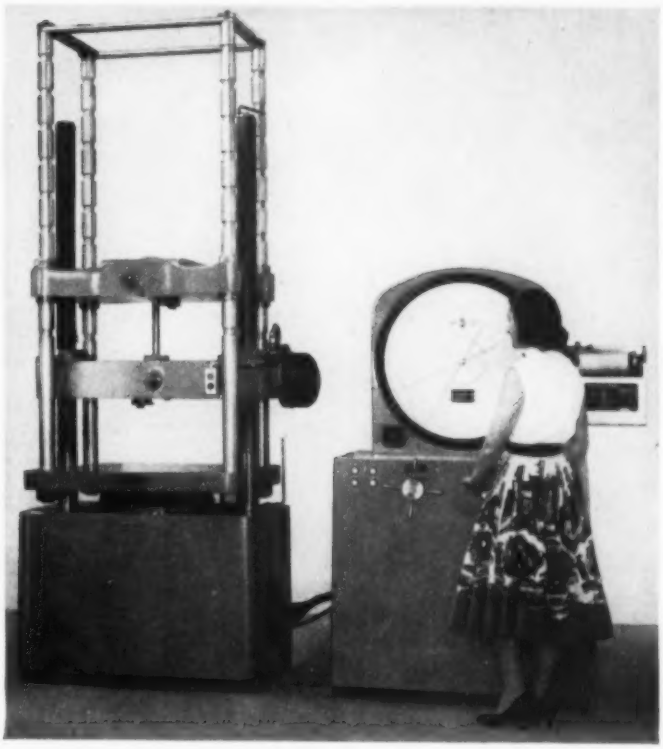

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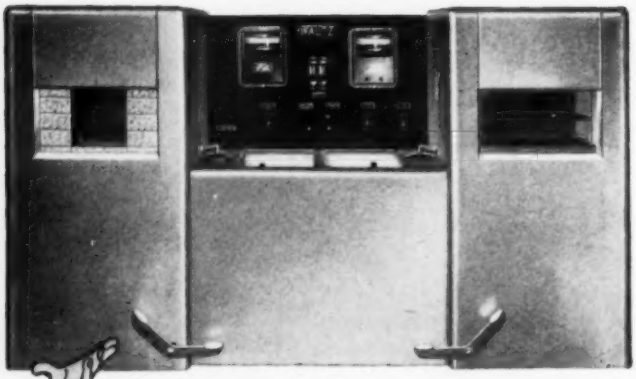

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Process of Bainite Formation

(Continued from p. 174)

nuclei. The growth was relatively slow and could be followed under the microscope. The rate of growth varied with the temperature and depended upon the composition of the austenite. The authors concluded that in the bainite range of temperatures, the difference in free energy between the austenite and the supersaturated ferrite is too small to permit the formation of martensite, because this reaction induces adverse strains. Bainite can form by coherent growth only when the removal of carbon from the bainite occurs to relieve the stresses accompanying the reaction. The driving force for the transformation is increased when the carbon content of the bainite is decreased. Carbon may be removed from the bainite either by precipitation or, in lower carbon steels, by the diffusion from bainite into austenite. At low temperatures, the precipitation mechanism is the dominant factor.

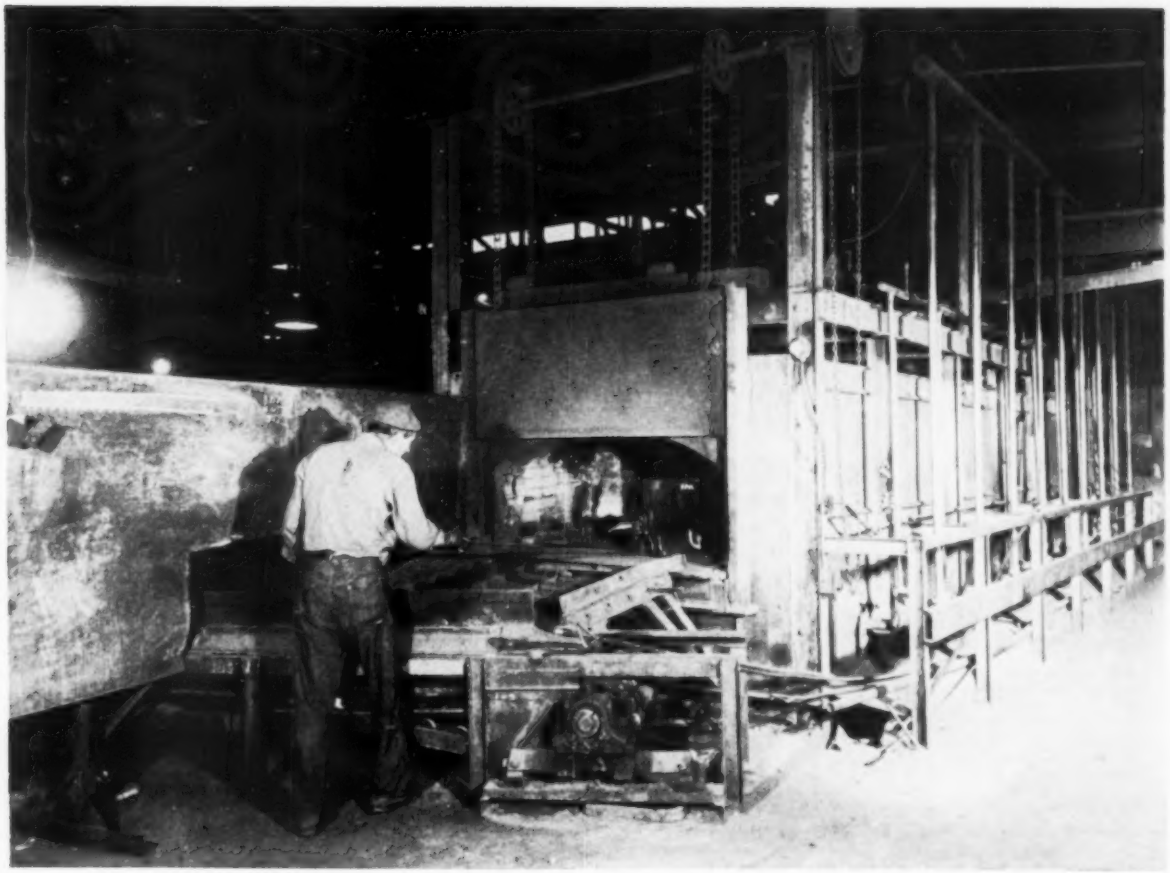
This investigation shows that the phase transformation in the bainite range occurs as a coherent growth process which is probably controlled at all temperatures by a diffusion process. E. R. PARKER

New Results on Oxygen in Gamma Iron*

IT HAS BEEN frequently suggested that many mechanical properties and metallographic structures, as well as corrosion resistance, are influenced by the oxygen in solid solution in iron. The object of this investigation was to determine the "solubility of oxygen" in gamma iron, the term "solubility of oxygen" being defined as the maximum amount of oxygen that can be taken up by iron before a separate oxide phase is formed. The published results on such absorption of oxygen are highly discordant. This may be due to failure to reach equilibrium between the solid phases present or to the presence of impurities in the iron.

(Continued on p. 178)

*Digest of "The Solubility of Oxygen in Gamma Iron", by J. A. Kitchener, J. O'M. Bockris, Molly Gleiser, and J. W. Evans, *Acta Metallurgica*, Vol. 1, Jan. 1953, p. 93.



Though essentially put in to stop abrasion, this...

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This furnace used to have a severe abrasion problem. It had a 3"-thick fireclay hearth covered by an alloy plate, and railroad I-beam skid rails. Used for preheating motor blocks, the skids had to withstand loads of up to 250 lbs. being dragged over them at furnace temperatures. The beams simply couldn't take it. They warped badly, and constantly needed straightening or replacing.

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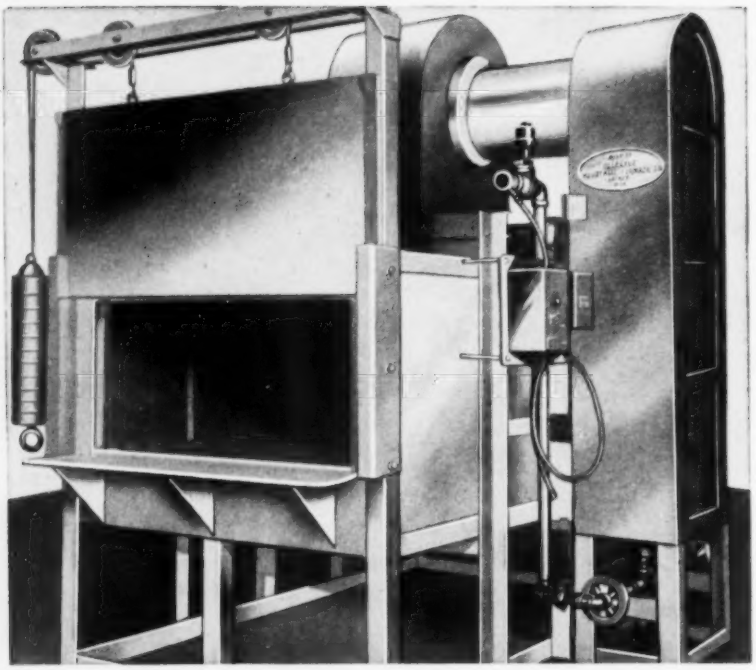

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New Results on Oxygen in Gamma Iron

(Continued from p. 176)

In the preliminary tests, the pick-up of oxygen was determined by the change in weight of thin iron foil heated in a controlled gas mixture of either H_2O plus H_2 or CO_2 plus CO in a molybdenum-wound, vertical alumina-tube furnace. All of the gas mixture compositions allowed an effective partial pressure of oxygen slightly smaller than that required to form Wüstite (nonstoichiometric FeO). After determining the dissolved oxygen, Sievert's law was used to calculate the amount of oxygen that would have entered iron in equilibrium with FeO. The small amounts of hydrogen or carbon dissolved simultaneously were not believed to have a significant effect on the oxygen in solid solution.

The following points were established:

1. At temperatures below 900° C. (1650° F.) the rate of oxygen solution was so slow that equilibrium could not be attained, even after heating a 0.002-in. iron foil for long periods of time. This appears to account for the gross discrepancies between the results of various workers who have attempted to equilibrate iron with iron oxide in the lower temperature range.

2. At 1000° C. (1832° F.) the solubility cannot exceed 0.01% oxygen by weight.

3. At higher temperatures, especially near 1400° C. (1040° F.) measurable amounts of oxygen were dissolved in the iron; for example, 0.05% at about 1375° C. (2507° F.) and 0.12% at 1465° C. (2670° F.). However, the iron samples were contaminated with silicon from the refractory tube.

4. Slightly impure iron foils show a very high "apparent solubility" of oxygen compared with high-purity iron.

5. High-purity iron foil, to which 0.06% manganese was added, showed an enhanced oxygen pick-up which roughly agreed with the amount expected by internal oxidation when assuming that an ideal solid solution of FeO-MnO is formed.

These observations show conclusively that slightly impure iron can absorb appreciable amounts of oxy-

(Continued on p. 180)

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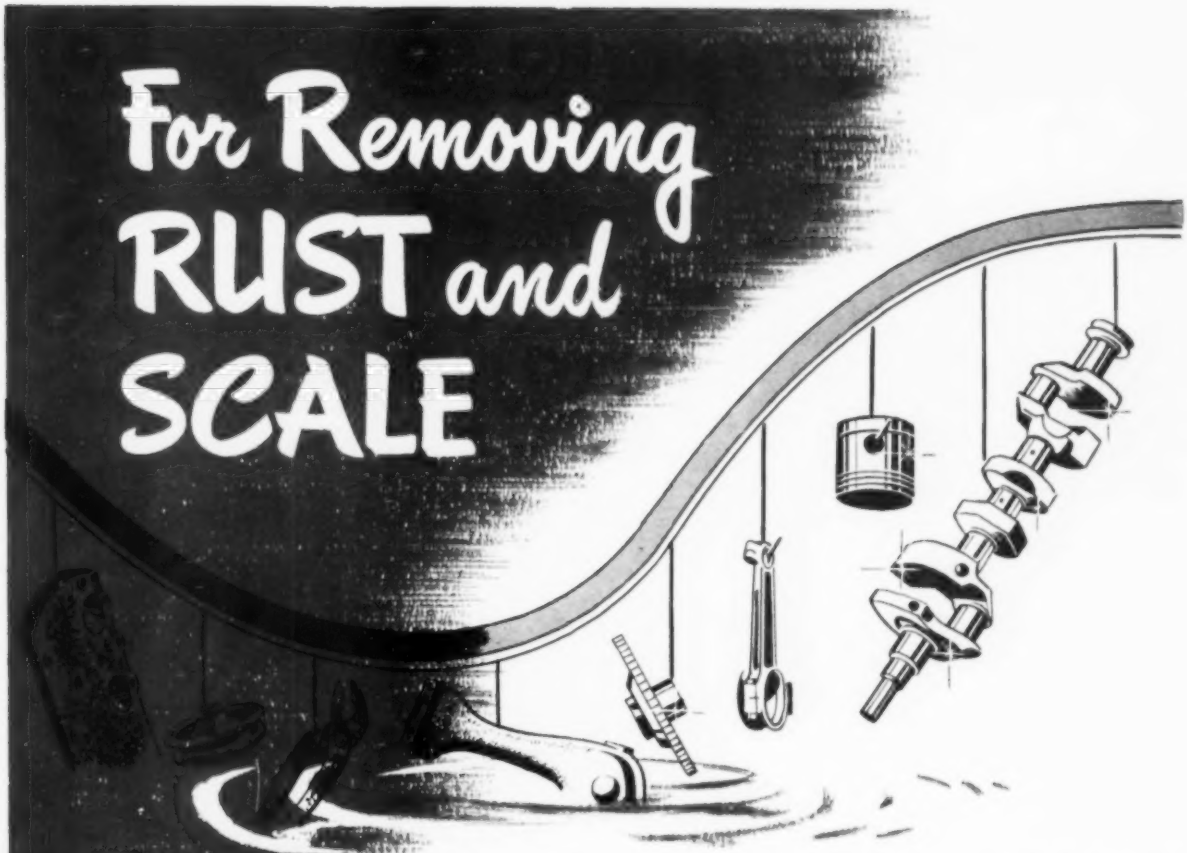

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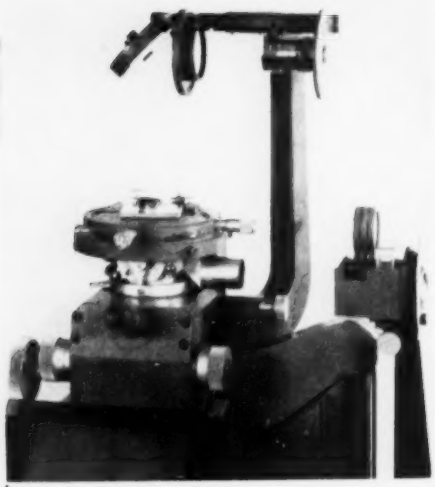

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New Results on Oxygen in Gamma Iron

(Continued from p. 178)

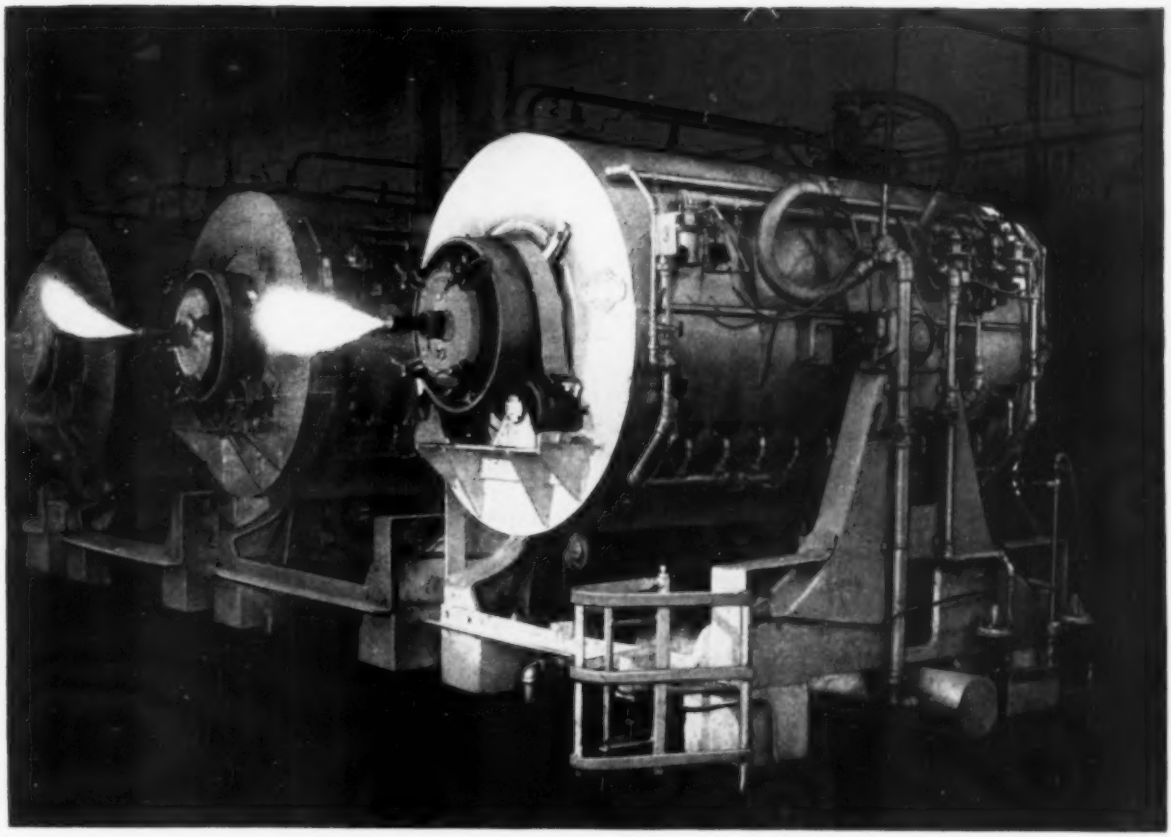
gen at oxygen activities where no oxide of iron can form. There appears to be no doubt that this oxygen forms oxide inclusions with elements having a higher affinity for oxyen than iron (internal oxidation). At very low concentrations, however, impurities such as silicon do not readily react to form the thermodynamically permissible phases. Probably, nucleation is difficult when such minute quantities of oxidation product have to be formed at the grain boundaries.

A new apparatus was devised to eliminate the contaminating effect of the hot refractories. The strips of high-purity iron were heated by their own electrical resistance while being subjected to a controlled CO-CO_2 atmosphere in an all-glass vacuum apparatus. The strips were first reduced with pure, dry hydrogen. Hydrogen was again used after the CO-CO_2 treatment to remove any oxygen dissolved in the iron as water vapor. The latter was measured as a gas after condensation from the hydrogen.

Three out of four high-purity irons were found to absorb 0.002±0.002% oxygen by weight in the temperature range of 1330 to 1432° C. (2425 to 2592° F.) when using a CO-CO_2 ratio of 0.171. The fourth sample had 0.004±0.002% oxygen. Since this sample had slightly higher impurities than the other three, the value of 0.002±0.002% oxygen was accepted as representing the gamma-range oxygen solubility, for the highest purity iron. Applying Sievert's law for the mean temperature of the gamma range resulted in a value of 0.003±0.003% oxygen, by weight, as the theoretical limiting solubility in iron in equilibrium with FeO. This value is lower than any recorded previously.

It should be emphasized that these results were obtained with high-purity irons. However, all the samples contained impurities exceeding 0.003%. Because of this, it was felt by the authors that the true solubility of oxygen in pure gamma iron may be less than 0.001%. The fact that the oxygen dissolved was independent of temperature indicates

(Continued on p. 182)



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In addition to being subjected to multiple, rapid reheatings, the retorts are exposed to carburizing gas atmosphere inside and oxidizing conditions outside.

Putting two and two together, 4 years' service under these conditions spells *excellent performance.* Yet this does not represent the full picture. Approximately 20% of the initial cost of D-H retorts can be recovered from scrap—an important economy feature.

Yes, for heat-treating equipment that is unexcelled for efficiency, economical service, and *long life,* Driver-Harris alloys are *unsurpassed.* Retorts made of world famous Nichrome* have averaged up to 24,000 hours in rotary gas carburizers operating at 1650°F., and 36,000 hours in vertical carburizing furnaces. Existing alloy conservation at present limits use to Chromax in such applications, and Chromax, too—as shown above—can "stand the gaff."

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New Results on Oxygen in Gamma Iron

(Continued from p. 180)

that the true solubility of oxygen in iron was not determined.

These very low results are not believed to be incompatible with the evidence that oxygen will diffuse through ordinary iron. In view of the ionic radii and lattice parameters, it was felt by the authors that the diffusion of oxygen in iron is intergranular. J. E. STUKEL

Oxiding—a Method of Hardening Metal*

THIS ARTICLE, written for readers of general scientific background, rather than for metallurgists, starts off with a consideration of the nature of hardening. A general picture is given of the atomic architecture of the metallic crystal, and how it is deformed plastically by one portion of the crystal slipping past another portion. Ease of slip (softness) is a function of the regularity of this original crystallinity. Anything which disrupts the geometric "smoothness" of the rows and ranks of atoms in the crystalline body will interfere with easy slip and increase the hardness. This is the familiar "slip interference theory" of hardening.

Mr. Meijering shows briefly how the commercial methods of hardening fit into this theory—the "martensitic" hardening of iron-carbon alloys, the "work" hardening of relatively pure metal, the hardness due to solid solution effects, the "precipitation" hardening of various metal solutions. In addition there is the recent finding that intense irradiation by neutron bombardment generally hardens soft metals. All of these involve the displacement of atoms from their natural sites or the production of secondary particles a few atoms in diameter. A useful degree of hardening is also associated with an enormously large number of these displacements, fairly uniformly distributed through the lattice very close one to another.

"Oxidation hardening, or rather hardening by internal oxidation, is

(Continued on p. 184)

★Digest of "Hardening of Metals" by J. L. Meijering; *Philips Technical Review*, January 1953, p. 203.

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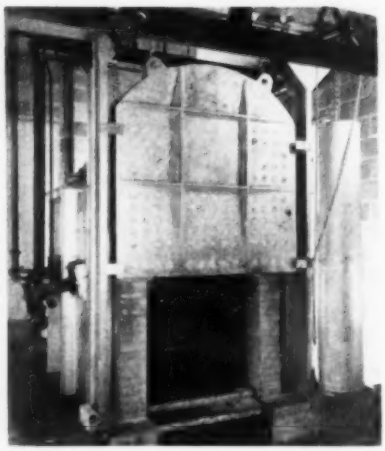

This car-type annealing furnace is an example of the heat treating furnaces designed and engineered by the Carl-Mayer Corp. This particular car bottom furnace was designed for the heat treatment of chain up to 2000°F. at Cleveland Chain & Mfg. Co. We also build furnaces for other uses, including aluminum and magnesium heat treating.

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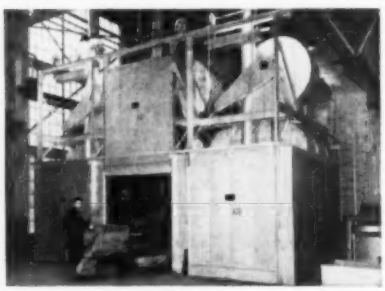

This battery of three aging ovens incorporates direct gas-fired recirculating air heating systems and other features which contribute to uniformity and faster, more economical production in a large aluminum company.

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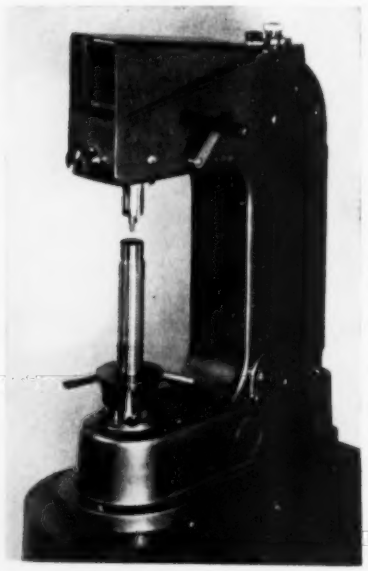

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OPTICAL INSTRUMENTS

Oxiding—a Method of Hardening Metal

(Continued from p. 182)

a method of hardening based on the formation of foreign molecules in the crystal lattice of the basic metal. For example, on heating in air silver in which 1.5 at. % of magnesium has been dissolved, oxygen diffuses into the metal and combines with the magnesium atoms to form molecules of MgO. These molecules deform the silver lattice considerably by their large dimensions. Consequently, the metal becomes harder—the Vickers hardness increases from about 40 to approximately 170." Since this action depends on time, it is obviously possible to have a case hardening effect. In fact, even after hundreds of hours at temperatures close to melting, the core will have a soft line down its middle.

In such an example it is necessary for the gas (oxygen) to be able to diffuse more rapidly into the metal (silver★) than the alloying element (magnesium) will diffuse to the surface, and the "affinity" of the solute (magnesium) for the gas (oxygen) must be considerably greater than that of the solvent (silver). If the latter stipulation is not met, large particles of compound will be formed rather than an infinite number of small ones—which is a condition of proper hardening.

No surface oxide forms on the silver in the above example. Copper will be quickly covered with a surface layer of Cu_2O, whereupon the ambient air may be replaced by inert oxygen and the oxide already formed will supply sufficient oxygen for the completion of the internal oxidation within the metal.

A few examples of oxidation hardening follow:

Solvent	Solute	Vickers Hardness Orig.	Vickers Hardness Oxided
Ag	1.5% Mg	40	170
Ag	1.5% Al	40	160
Ag	1.5% Be	40	135
Ag	1.5% Mn	40	140
Cu	1.5% Mg	40	105
Cu	1.5% Al	40	105
Cu	1.5% Be	40	165
Cu	1.5% Ti	40	125
Cu	1.5% Zr	40	100

★Other metals of this sort are copper and nickel.

(Continued on p. 186)

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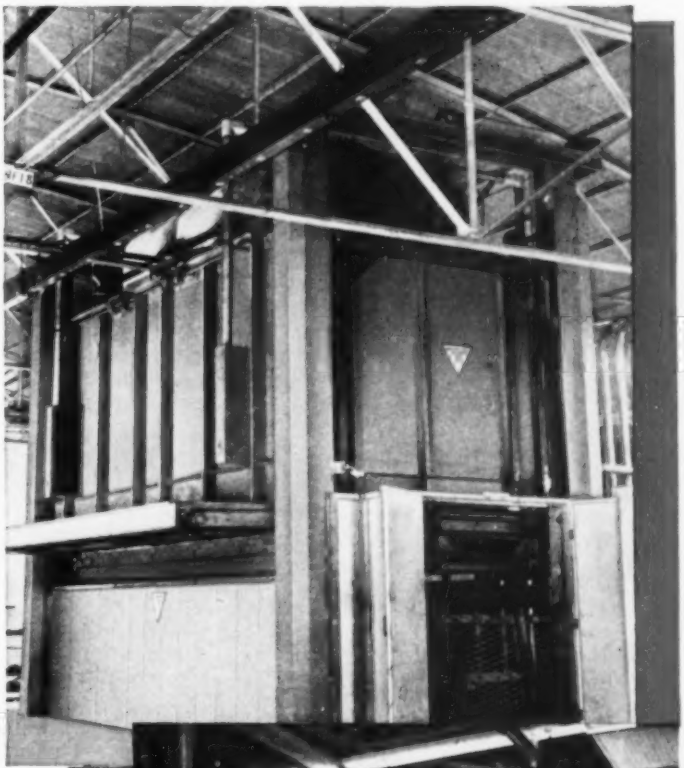

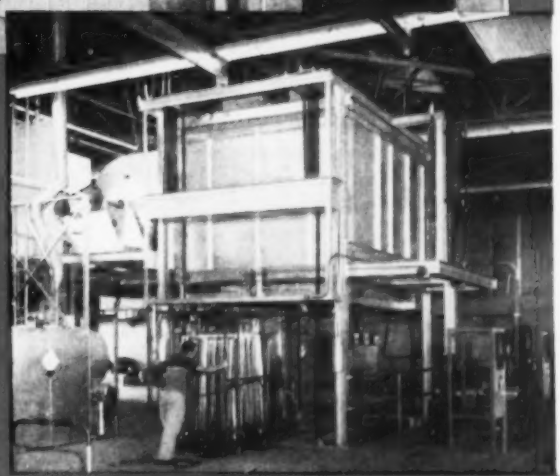

TOP PHOTO: This DESPATCH furnace is being used for the solution heat treating of aluminum and aluminum alloy shapes. It is heated by 270 kw electric heater. Load passes through fog quench chamber to quench tank. Complete quench less than 10 seconds.

BOTTOM PHOTO: DESPATCH quick quench furnace of similar design being operated on defense production. Speed, uniformity and economy are also being achieved with this modern, fully automatic unit.

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Cold-Roll FORMING MACHINES
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Oxiding—a Method of Hardening Metal

(Continued from p. 184)

No example of the oxidation hardening of iron could be found, although oxygen can diffuse readily into hot iron. On the other hand, nitriding of steel is a process of the same general nature widely used.

Coagulation of oxides also causes "inner oxide films" in some alloys containing rather strong concentrations of base elements (such as 95-5 Cu-Be alloy). These more or less coherent layers of oxide, roughly parallel to the metal surface, may impede the internal oxidation in the deeper parts of the metal.

The hardness obtained by oxidation hardening is less sensitive to subsequent treatment at high temperatures than that obtained by cold working or precipitation hardening, which is a definite advantage. The occurrence of intercrystalline brittleness is a disadvantage. E.E.T.

A Canadian View of Atomic Power*

CANADA has a very fine experimental reactor at Chalk River, and another under construction estimated to cost $30,000,000. They use natural uranium for fuel and heavy water for moderator. Their neutron efficiency is not high enough to work as a true "breeder" reactor, although it should be remembered that operations involve the production of a neutron by fission of an atom of U^{235}, and its capture by an atom of U^{238}, causing its transformation into plutonium—an element which itself is fissile and thus takes place of the original atom of U^{235} which has disintegrated. A normal medium-power reactor could not be expected to produce as much plutonium as the uranium^{235} it consumes, most of the loss being due to absorption of neutrons in the cooling system and walls of the reactor core. The main point is that there really is not any great economic difference between a reactor which is

(Continued on p. 188)

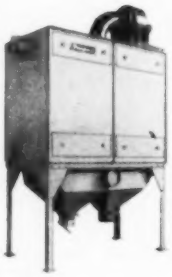
*Digest of "Development of Power From Atomic Energy in Canada" by I. N. MacKay; *Engineering Journal*, June 1953, p. 699.

PANGBORN SPEEDS UP PRODUCTION, LOWERS COST

WITH PRECISION FINISHING . . .

Pangborn Hydro-Finish Cabinet—Removes scale and directional grinding lines . . . holds tolerances to .0001" and prepares surfaces for painting or plating. Liquid blast reduces costly hand cleaning and finishing of molds, dies, tools, etc. Models from . . . **$1410** and up.

AND DUST CONTROL



Pangborn Unit Dust Collector—Traps dust at the source. Machine wear and tear is minimized, housekeeping and maintenance costs reduced. Solves many grinding and polishing nuisances and allows reclamation of valuable material. Models from . . . **$286** and up.

Pangborn Blast Cleaning Machines for cleaning tanks, bridges, structures quickly and economically. Portable and stationary models, 6 sizes . . . $188 and up. Cabinet for cleaning small metal parts better and faster . . . $319 and up.

Write for details on these machines to: PANGBORN CORPORATION, 1800 Pangborn Blvd., Hagerstown, Md.

Look to Pangborn for the latest developments in Blast Cleaning and Dust Control equipment

Pangborn
STOCK UNITS

It's easy to get any brazing output you want with *EASY-FLO* SILVER BRAZING ALLOYS

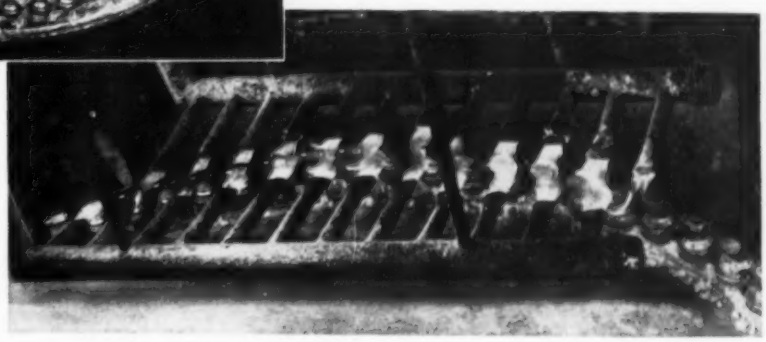
Here's the formula:

1. **Prepare the assemblies for brazing with the alloy preplaced in a form suited to the joints.**
2. **Use a fast heating method such as oxyacetylene torch, gas-air burners, electrical induction, furnace, etc.**
3. **Plan a set-up that will keep assemblies moving steadily to and through the heating station.**

Here's an example from a company specializing in metal joining — Salkover Metal Processing of New York, Inc., Long Island City, N. Y.

Operator at right puts caps on turntable and alloy squares on caps. He also flips finished assemblies into water barrel. Operator at left applies Handy Flux and sets valves on top of alloy. Output — 720 per hour — or one every 5 seconds — and every one strong and permanently leak-tight.

Above are the parts — a brass valve and the cap of a fire extinguisher body, with the 9/16" square of .005" EASY-FLO 35 used to join them. At left is the turntable and gas-air burner set-up, with close-up of burner station below.



GET **BULLETIN 20** FOR FULL DETAILS

It covers correct joint design, alloy forms for preplacement and fast heating and production methods. Also tells why you are assured of strong, leak-tight joints when you braze with EASY-FLO low-temperature silver brazing alloys.

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ORIGINATORS OF EASY-FLO & SIL-FOS

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No matter what your wire or insulation requirements may be, you can depend on Gordon "Serv-Rite" insulated wire for pyrometers—recognized as a standard of highest quality for nearly half a century. All "Serv-Rite" wire is now manufactured in the new, completely modern Gordon plant, employing up-to-date equipment and machinery, supervised and operated by skilled technicians—your guarantee of continued precision quality. In addition to maintaining large stocks of all common types of wire, Gordon will manufacture special insulation, in long or short runs, to suit your individual needs and meet your most rigid specifications.

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A Canadian View of Atomic Power

(Continued from p. 186)

just breeding and one which just is not.

At any rate, the plutonium produced remains in the fuel and contributes to the nuclear reaction to an increasing extent as the original fissile material is used up. This greatly extends the amount of energy which may be extracted from the natural fuel, without any chemical or other reprocessing. The importance of this is obvious; at Chalk River considerable effort has been devoted to developing methods of obtaining more energy from the fuel. To date it has been found practicable to get many times as much energy from the uranium fuel rods as was possible three years ago.

A characteristic of a reactor is that, within wide limits, its power or heat release is independent of its size—once the size is sufficiently large. Since size and cost go hand in hand, it follows that a low-powered reactor is uneconomical. It is likely, also, that units will have to produce 500 megawatts of heat per hour from a volume which might be a cylinder a dozen feet in diameter with about the same height.

At the present time, costs of a commercial power plant are largely speculative. It is necessary to build one to know—also to learn how to build better ones. Based, however, on the estimated costs and efficiency of the new Chalk River reactor, Mr. MacKay estimates that a 125,000-kw. atomic power generating station will cost:

Heat producer	$20,000,000
Turbo-generators	10,000,000
Transformers	6,250,000
TOTAL	$36,250,000

or $290 per kw. as compared with 1950 costs of hydro-electric stations in Ontario of $215, and $160 for steam-electric plants in the United States.

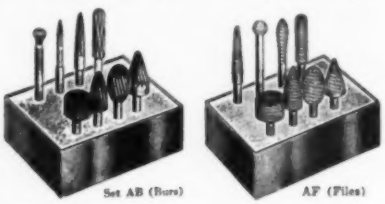
Obviously, no privately owned firm would build atomic power plants as long as hydro-electric sites are available, but the only sizable one left in Ontario is the St. Lawrence. It follows that in the relatively near future, at least in Ontario, competition with steam and not hydro power should be considered.

(Continued on p. 190)

MARTINDALE

ROTARY BURS AND FILES

Made of high-speed steel. Produced in our own factory where uniform hardness is assured by heat-treating in electric furnaces on which the temperature is closely controlled by electric eyes.



Set AB (Burs) AF (Files)

Sets AB & AF	Per Set
1 set	$11.05 net
2 to 11 sets	9.75 net
12 or more	8.45 net

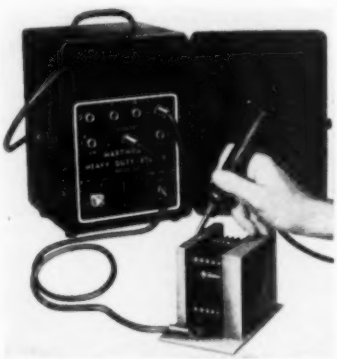
The above sets, with ¼" diameter shanks, are composed of the 8 most popular sizes for general use.

Over 200 sizes and shapes (total over 75,000 pieces) are carried in stock for immediate shipment.

DEMAGNETIZER—Model D-3

This tool quickly and easily removes magnetism from cutting tools such as cutters, drills, saws, etc., and thus keeps them free from chips and metal-slivers that reduce production. Cuts cost of tool maintenance.

HEAVY DUTY ETCHER



Model A-A has wide use as a production-line etching tool. With six heats it is effective on small parts and also on large pieces such as shovels, castings, etc. Complete with ground lead, heavy metal case, etc.

Send for new Catalog No. 29 with 64 pages of Maintenance, Production and Safety Equipment.

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1372 Hird Avenue, Cleveland 7, Ohio

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Name	No. of Furnaces
AC Spark Plug	15
Aeroproducts Division	7
Aluminum Co. of America	34
Allegheny Ludlum Steel	8
American Brass Co.	11
American Can Company	4
American Car & Foundry Co.	2
American Optical Company	14
American Steel & Wire Co.	8
Baker Ice Machine Co.	3
W. O. Barnes Co.	4
John Bath & Co.	4
Bath Iron Works	4
Bell Telephone Labs.	10
Bendix Aviation	6
Bethlehem Steel Co.	66
Bohn Aluminum and Brass Corp.	11
Boston Wire Stitcher Co.	2
Briggs Mfg. Co.	10
Brown-Lipe Chapin Div. GMC	7
Brown & Sharpe Mfg. Co.	15
Buick Motors	8
Bulova Watch Co.	18
Carnegie Illinois Steel Corp.	14
Chase, Brass & Copper Co.	3
Chevrolet Motors	10
Chicago-Latrobe Twist Drill	8
Chrysler Corp.	14
Cleveland Cutter & Reamer	5
Clinton Engineer Works	5
Commercial Steel Treating Corp.	12
Crucible Steel Co. of America	5
Denver Fire Clay Co.	5
Dept. of Commerce	2
Detroit Steel Treating	3
Dow Chemical Co.	5
Eastman Kodak Co.	23
Easy Washing Mach. Co.	4
Eclipse Aviation	11
Eclipse Machine Division	4
Thomas A. Edison, Inc.	4
Elliott Company	5
Evans Case Company	4
Ex-Cello Corp.	13
Fisher Body Corp.	6
Ford Motor Co.	73
Frankford Arsenal	6
Frigidaire Corp.	21
General Electric Co.	35
Grinnell Co.	4
General Tire & Rubber	5
Gillette Safety Razor Co.	4
Gorham Mfg. Co.	2
Gorham Tool Co.	7
Greenfield Tap & Die	14
Hamilton Watch Co.	4
Hanson-Whitney Machine Co.	3
Hemphill Co.	3
B. F. Hirsch Inc.	6
U. S. Hoffman Mach. Corp.	4
W. H. Howitt Inc.	13
Hudson Motor Car Co.	5
Hughes Tool Co.	4
Hyatt Bearing	5
Hytron Corp.	7
Int. Business Mach. Corp.	3
International Harvester Co.	11
Jack & Heintz Co.	13
Jones & Laughlin Steel Corp.	10
Jones & Lamson Co.	3
Walter Kidde Co.	3
Kollsman Instrument Co.	6
Koppers Co.	2
Lamson & Sessions	5
Lansdale Tube Works	10
D. E. Makepeace Co.	7
Marion Steam Shovel Co.	3
Mass. Inst. of Technology	7
McCord Radiator & Mfg. Co.	4
Mergenthaler Linotype Co.	7
Merriman Bros.	4
Michigan Tool Co.	5
Moraine Products	5
Morse Twist Drill Co.	3
Nat. Bureau of Std.	2
Nash Kelvinator Corp.	4
Nat. Cash Register Co.	2
Nat. Supply Co.	6
Nat. Union Radio Corp.	11
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Ohio State University	4
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Oldsmobile Motor Works	4
Packard Motor Car Co.	11
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Remington Arms Co.	4
Remington Rand, Inc.	5
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This list shows some of the Hayes furnace users, serving to give you a good idea of their wide acceptance.

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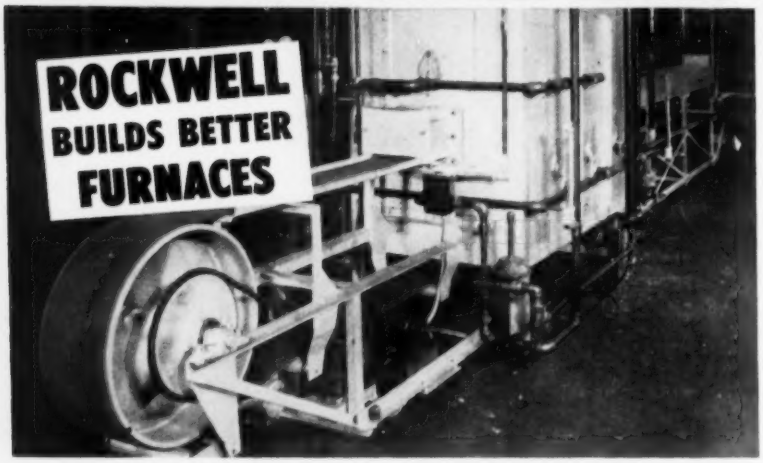
FOR SINTERING POWDERED METALS



Continuous Mesh Belt Conveyor Furnaces, with moderate width and length of belt, for medium capacity in sintering pressed ferrous and non-ferrous metal powders.

Continuous Roller Hearth Furnaces for larger capacity of pressed metal products loaded in trays.

Batch Type Furnaces in many sizes.

Fuel-Fired Furnaces for temperatures to 2000° F., equipped with alloy muffle.

Electric Furnaces with resistance elements for temperatures to 1800° F. and Globars to 2400° F.

Cooling Sections may be provided for cooling product to any required temperature.

Provision in furnace and cooling section for sintering in protective atmosphere.

Get our recommendations to fit your requirements.

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The Clark Hardness Tester is precision built to give guaranteed precision results. Thousands of Clarks, with years of service all over the world, attest to this.

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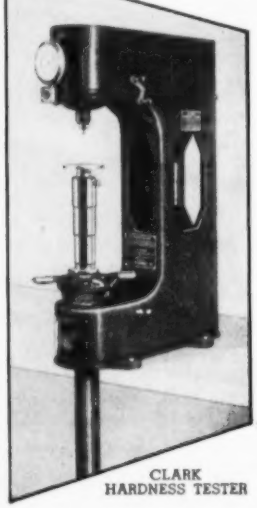
Before you invest in any hardness tester, get the facts about the low price, speedy delivery, and *guaranteed accuracy* of the Clark. Write today.



CLARK HARDNESS TESTER

CLARK INSTRUMENT, INC. 10202 FORD ROAD DEARBORN, MICH., U.S.A.

A Canadian View of Atomic Power

(Continued from p. 188)

Mr. MacKay's figures for annual operating costs are:

Amortization (10%)	$3,625,000
Fuel, operations and maintenance	2,000,000
TOTAL	$5,625,000

or 7.5 mils per kw-hr. (compared with average of 5.32 mils from steam plants in the U. S.). It can be concluded that the atomic power station would have some chance of competition with steam, even if no revenue were obtained from the sale of plutonium. A reasonable market for this byproduct would strongly favor the atomic power station.

L. R. Hafstad, director of reactor development for U. S. Atomic Energy Commission, is quoted as saying: "I hope, sooner or later, our country will be in the position of declaring that for stationary power plants and large blocks of power, we cannot afford to use petroleum. U^{235} ought to be good enough."

Mr. MacKay concludes: "It should be borne in mind that the demand for power is expected to exceed the possible supplies on the continent sometime between 1975 and the year 2000 unless entirely new sources of energy are developed."

Permanent Magnets From Micropowders*

IT IS NOW possible to make satisfactory permanent magnets from pure iron. Such magnets are being made in Great Britain, these being pressed from very fine powders known as micropowders. The coercive force of iron powder depends on its size. Powders, prepared by high-temperature reduction of iron compounds, above 1 micron (10^{-4} cm. in size), are known to be useful because of their low losses. On the other hand, powders less than 0.1 micron in size have high coercive forces and can be made into useful permanent magnets.

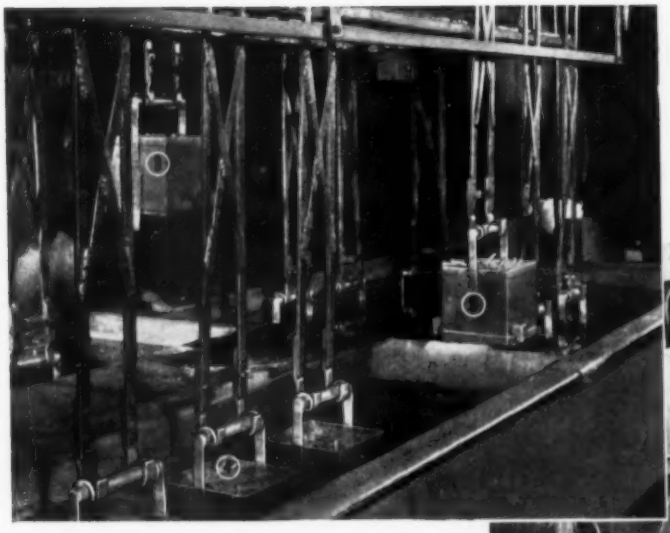
It has been found that coercive forces approaching 1000 oersteds

(Continued on p. 192)

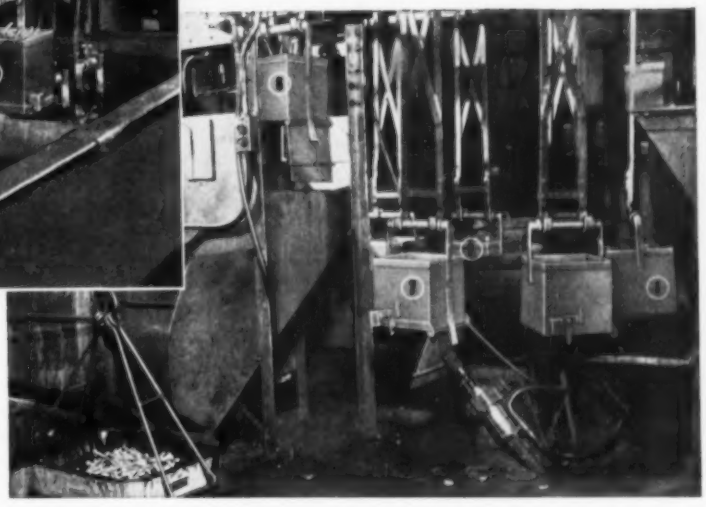
★Digest of "Iron Powder Magnets," *Engineer*, May 22, 1953, p. 740-741.

ROLOCK

FABRICATED HEAT AND CORROSION RESISTANT ALLOYS



GREATER PRODUCTION *thru an* AUTOMATIC PICKLE-WASH CYCLE *for* Valve Stems *at* A. SCHRADER'S SON



Shown in the two photographs are start-to-finish steps of an automatic oval travel cycle for bright dips and washes of Schrader brass valve stems. The baskets (9″ x 9″ x 9″) were made by Rolock from 18-8 stainless steel to carry 75-lb. loads. This system replaced hand pickling and has greatly increased production, lowered hour costs considerably.

Basket No. 1 is hopper loaded . . . Nos. 2, 3, 4, 5 show progressive positions thru tanks. At No. 6, bottom latch of basket has been automatically tripped, releasing load thru a chute to carrier . . . and at No. 7, bottom is closed by an air gun and is ready for reloading. Some baskets have been in use for 9 years.

This is a typical example of Rolock cost-reducing equipment for handling metal parts thru finishing operations . . . either heat or corrosion resistant baskets, crates, trays, retorts, muffles, tanks, sinks, etc.

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Whatever your requirements,

SEND FOR CATALOGS B-8 (Heat Treating) or B-9 (Corrosion Resistant).

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The Chromate Finish For Producing Inhibited and Lustrous Finishes on Copper, Brass or Bronze.

- Produces a permanent lustrous finish even in recessed areas.
- Stands over 100 hours standard salt spray
- Assures very long life
- Can be handled immediately after treatment cycle — no staining or finger marks
- Replenishment required only to replace dragout
- Exhaust of bath in use is optional — not required
- Excellent paint bond qualities

Specify
New Luster-on®
COBRA
for

- Inhibited and lustrous finishes on copper, brass or bronze
- Use on solid or plated copper or brass
- Cleaning and deoxidizing copper and brass parts
- Removing flux on soldered parts

Luster-on — the first in the field and still the leader

Write for full data sheets and send a part for free processing

*Patent applied for

THE Chemical CORPORATION
70 Waltham Ave., Springfield 9, Mass.

Permanent Magnets From Micropowders

(Continued from p. 190)

could be obtained from pure iron powder made by reducing ferrous formate in dry hydrogen. The best results were obtained with a particle sizes of 0.01 to 0.1 micron. Below this size range coercive force rapidly drops off. These experimental powders are difficult and hazardous to prepare, since they rapidly oxidize spontaneously in air and must be kept under a liquid such as benzene. Theoretically, properly oriented elongated iron particles of the right size should have a coercive force approaching 10,000 oersteds.

Magnets made from iron powder were first developed and patented by the Société d'Electro-Chimie d'Electro-Metallurgie et des Aciéries Electriques d'Ugine, in France. "Gecalloy" powder magnets are now being made under license in Great Britain by Salford Electrical Instruments, Ltd.

Permanent magnets are made in quantity by high-pressure molding of the powders prepared by low-temperature hydrogen reduction of iron compounds. Their density is 4 to 5 g. per cc., a little over half that of iron. After pressing, they are sprayed with a plastic and dried in infrared ovens. They can either be pressed alone or with a binder. The latter greatly increases their electrical resistivity. The powders can be molded to accurate dimensions without final grinding. The low temperatures used permit the inclusion of shafts, pole pieces, or other metal inserts.

In practice, powders containing up to 30% cobalt are being made. The 30% cobalt material has an energy product of 1.7 million gauss-oersteds, comparable to that of Alnico II. The lowest grade powder magnets have an energy product of 0.5 million. The utilization of cobalt, in terms of energy product per pound of cobalt, is superior to that in cobalt permanent magnet steels.

These magnets have isotropic magnetic properties. The ratio of remanence to coercive force can be widely varied by changing the pressing technique, giving the designer a range of properties which would otherwise involve a number of different alloys.

J. J. Becker

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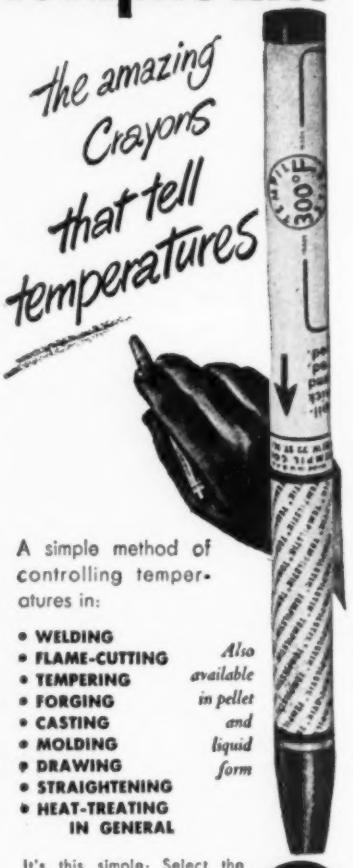

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- **HEAT-TREATING IN GENERAL**

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It's this simple: Select the Tempilstik® for the working temperature you want. Mark your workpiece with it. When the Tempilstik® mark melts, the specified temperature has been reached.

$2 each
gives up to 2000 readings

Available in these temperatures (°F)

113	263	400	950	1500
125	275	450	1000	1550
138	288	500	1050	1600
150	300	550	1100	1650
163	313	600	1150	1700
175	325	650	1200	1750
188	338	700	1250	1800
200	350	750	1300	1850
213	363	800	1350	1900
225	375	850	1400	1950
238	388	900	1450	2000
250				

FREE —*Tempil® "Basic Guide to Ferrous Metallurgy"* — 16¼" by 21" plastic-laminated wall chart in color. Send for sample pellets, stating temperature of interest to you.

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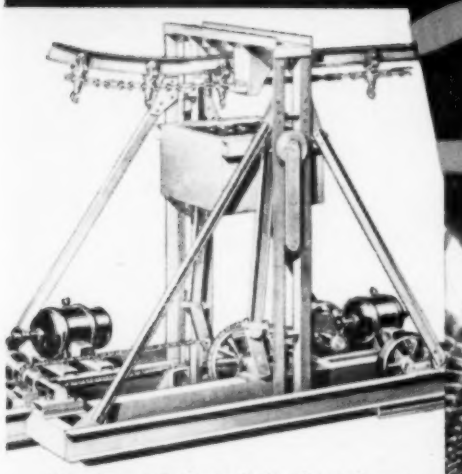
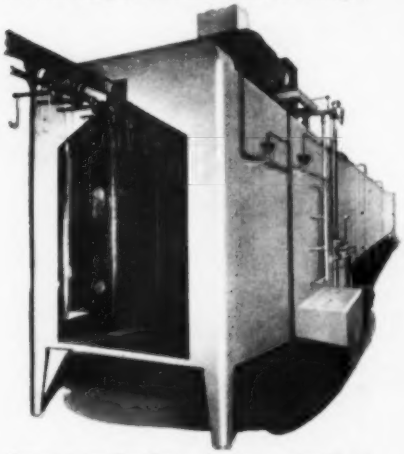


Mahon Automatic Dip-Coating Machine. Paint tank moves up and forward at conveyor speed to immerse parts. It then lowers away and moves back to its original position and repeats. Paint Level and Temperature is maintained by continuous circulation through Flexible Lines.

Mahon Conventional Type Hydro-Filter Spray Booths, with "Hydraire" Flood Sheet, Designed to meet the Specific Requirements of a Home Appliance Manufacturer.

. . . the EXPERIENCE that goes into the PLANNING and ENGINEERING of MAHON EQUIPMENT is the item of GREATEST VALUE to YOU!

Interior View of Typical Mahon Dip-Coating equipment. The Finish Baking Oven is located above this enclosure.



Typical Mahon Flow Coating Machine and Drip Tunnel. Automatic controls and equipment can be provided to maintain constant temperature of coating material.

Should YOUR PRODUCT be SPRAYED, DIPPED or FLOW COATED? or does it demand a COMBINATION of these COATING METHODS?

In some plants, where our advice on finishing methods has been sought, we have found parts being flow coated when substantial savings could have been effected in the over-all finishing costs through the employment of the dip method—savings in thinner, paint, initial cost of equipment and maintenance...and the dip method, in this particular operation would have provided a better finish with fewer rejections. It is therefore wise to get expert advice when confronted with a finishing problem, regardless of what the part or product may be. Many factors enter into the basic and all-important decision on method or combination of methods to be employed to produce the finest results at the lowest possible unit cost. Mahon engineers, with a background history covering thousands of complete finishing systems—including Dip, Flow Coating and Spray Equipment—are in a position to make sound, unbiased recommendations on the "HOW" to finish any product under any conditions or production requirements. Over thirty years of experience in planning, designing, building and installing finishing systems of every type for every conceivable product painted on a production basis, has equipped Mahon engineers with a wealth of technical knowledge and practical know-how not available to you elsewhere . . . can you afford to rely on less when so much is at stake? See Mahon's Insert in Sweet's Plant Engineering File, or write for Catalog A-654.

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Engineers and Manufacturers of Complete Finishing Systems—including Metal Cleaning, Pickling, and Rust Proofing Equipment, Hydro-Filter Spray Booths, Dip and Flow Coaters, Filtered Air Supply Systems, and Drying and Baking Ovens; Core Ovens, Heat Treating and Quenching Equipment for Aluminum and Magnesium, and other units of Special Production Equipment.

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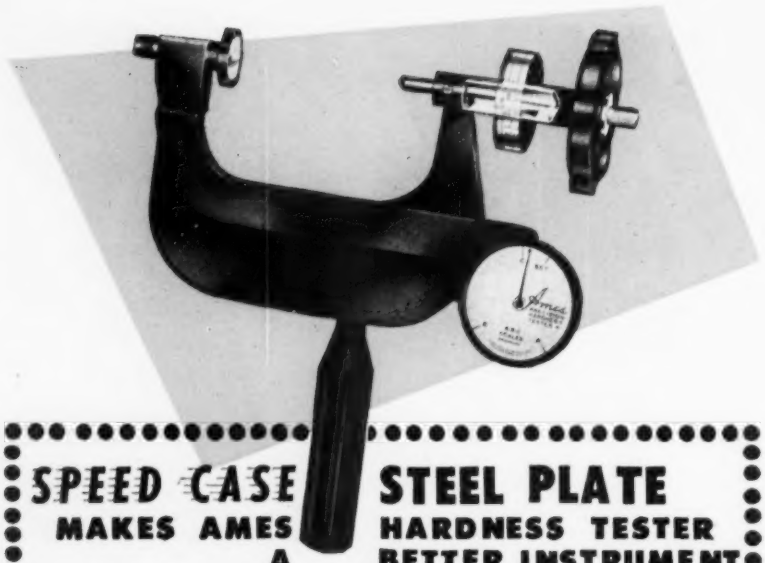

SPEED CASE STEEL PLATE MAKES AMES A HARDNESS TESTER BETTER INSTRUMENT

A Model 4 Ames Portable Hardness Tester manufactured by Ames Precision Machine Works, Waltham, Mass. is shown above. The dial is direct reading, indicating Rockwell A, B or C scale hardness on thicknesses up to 4".

Frame of the Ames Model 4, and several other models, is machined from **Speed Case** (X1515) low carbon, open hearth steel plate, supplied in flame cut blanks, as shown at right. The machined frame is shown in lower view, after magnifier retaining arm (1) and dial support (2) have been silver soldered to frame.

Speed Case has proved ideal for this application for three reasons: (1) Available flame cut to close tolerance. (2) Ease of machining, longer tool life, more readily polished and (3) Superior physical properties rendering it more suitable for a precision instrument.

Probably one of the **Speed Steels—Speed Case, Speed Treat** or **Speed Alloy**—can cut your costs while improving your product. **Send for literature.**

Speed Steels

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Produced by W. J. Holliday & Co., Inc., Speed Steel Plate Division, Hammond, Indiana. Plants: Hammond and Indianapolis, Indiana

Swarf Recovery*

THE TERM "SWARF" used in England is the approximate equivalent in North America of "nonferrous scrap metal," although it includes grindings and floor sweepings as well as machine cuttings and borings.

Mr. Thews urges the importance of starting right at the source to separate and keep separate metal of varying composition. Minimum classification would be white metals, light metals, and copper-base material. Considerable effort is warranted to avoid contaminating any of these with ferrous metal. He draws attention to the desirability of drying all such material to avoid the steadily increasing oxidation products. The large surface area of swarf compared to its weight can easily result in 25% of oxidized metal, which naturally reduces recovery by simple melting.

We are reminded that finely divided iron cannot readily be removed by magnets, as the particles adhere strongly to the swarf. The desirability of removing oil and grease is mentioned. Sometimes the values recovered may offset some of the operating costs. Solvent methods of oil extraction are discussed and reasons advanced for favoring trichlorethylene over carbon tetrachloride. (Modern commercial solvents are frequently to be preferred to either of these chemicals.) The simple process of burning off the oil also has its place.

The merits of briquetting and baling are touched upon, and details are given for a homemade baling machine where the cost of a modern commercial machine is not warranted by the small amount of material to be handled.

Those having swarf consisting of a mixture of fusible white metals and copper-base alloys will be interested in two recovery units described in detail with sketches. One consists of an inclined revolving wire mesh cylinder operating in a furnace the temperature of which is kept between 750 and 850°F.; the white metal melts and drains away and the copper-base material passes on substantially free from the white metal.

H. J. ROAST

★Digest of "Metallurgical Treatment of Swarf", by E. R. Thews, *Metal Industry*, Dec. 21, 1952, p. 521; Dec. 28, 1952, p. 535; Jan. 4, 1953, p. 7.

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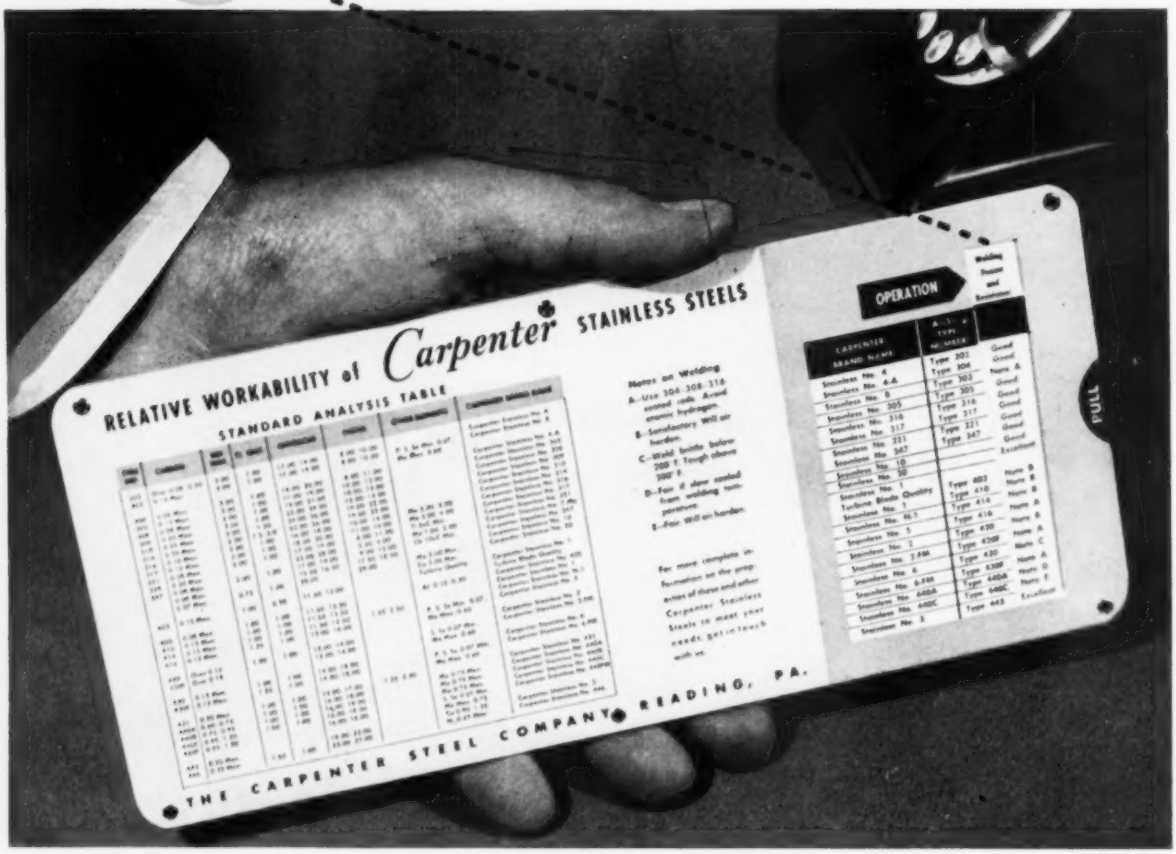

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The new Carpenter Stainless Slide Chart quickly gives you information your men need to know. It gives the relative workability for many grades, useful information for jobs where you do *blanking, deep drawing, forging, heading, machining, welding,* etc. You will also find a complete table of information on the physicals for the Stainless grades. Just drop us a note, on your company letterhead indicating your title, and we will put your Carpenter Stainless Slide Chart in the mail for you.

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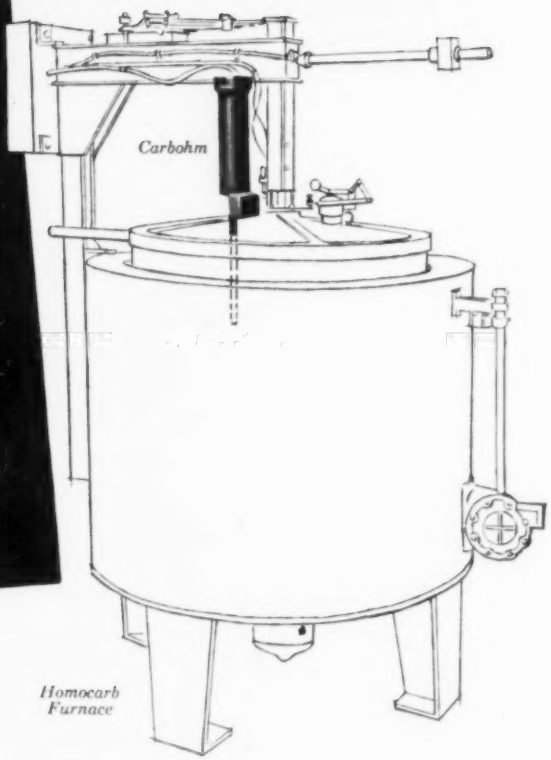
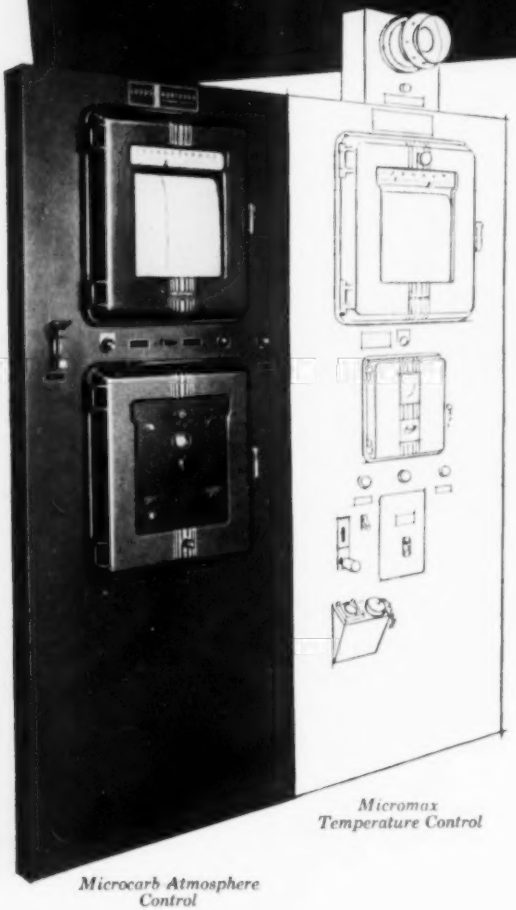


Homocarb Furnace



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The addition of Microcarb Control broadens the scope of the Homocarb Method to handle more types of heat treatments and steels than ever before. Microcarb Control provides automatic control of the active carbon in the furnace atmosphere . . . a control which is simple to set, and which draws a continuous record of percent carbon for each heat-treat cycle.

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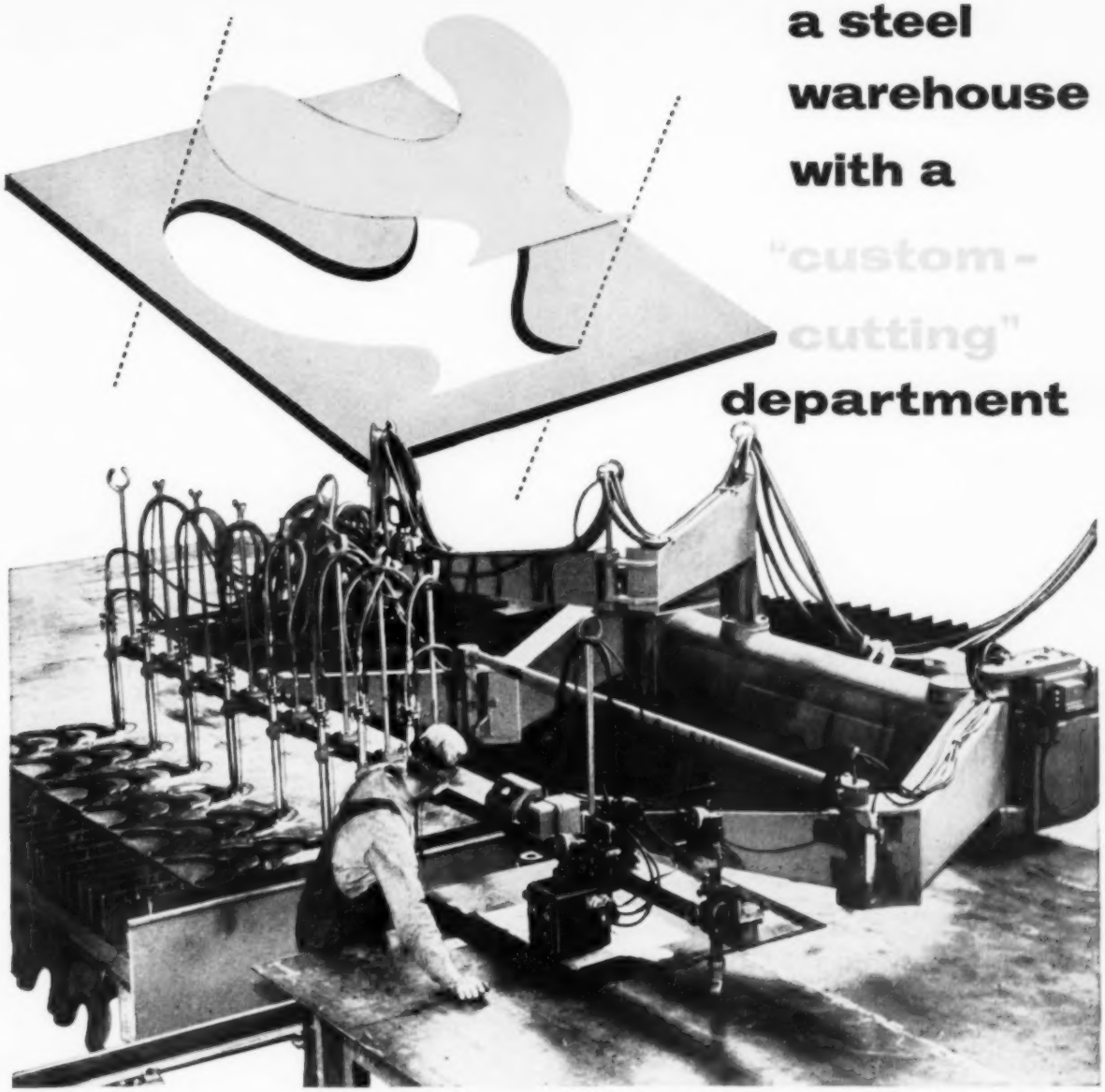
a steel warehouse with a "custom-cutting" department



That's McCormick Steel of Houston, Texas! By installing an Airco No. 50 multi-torch cutting machine, they've boosted steel orders with an entirely new type of service . . .

Here's how it works: customers supply an outline drawing or paper cutout of the required part. An "electronic eye" traces the guide with hairline accuracy. Irregular shapes, inside and outside square corners, obtuse angles, slim slots and intricate contours — the Airco No. 50 Travograph takes 'em all in stride. Circles up to 12 feet in diameter — thicknesses up to 6 inches! By keeping all 8 torches in operation, McCormick mass produces intricate shapes so accurately that further machining is, in most cases, unnecessary.

The Airco No. 50 Travograph cuts light plates, heavy slabs, billets or forgings . . . to minute tolerances . . . with virtually no limit on shape or size. Complete details are available by contacting your nearest Airco office.

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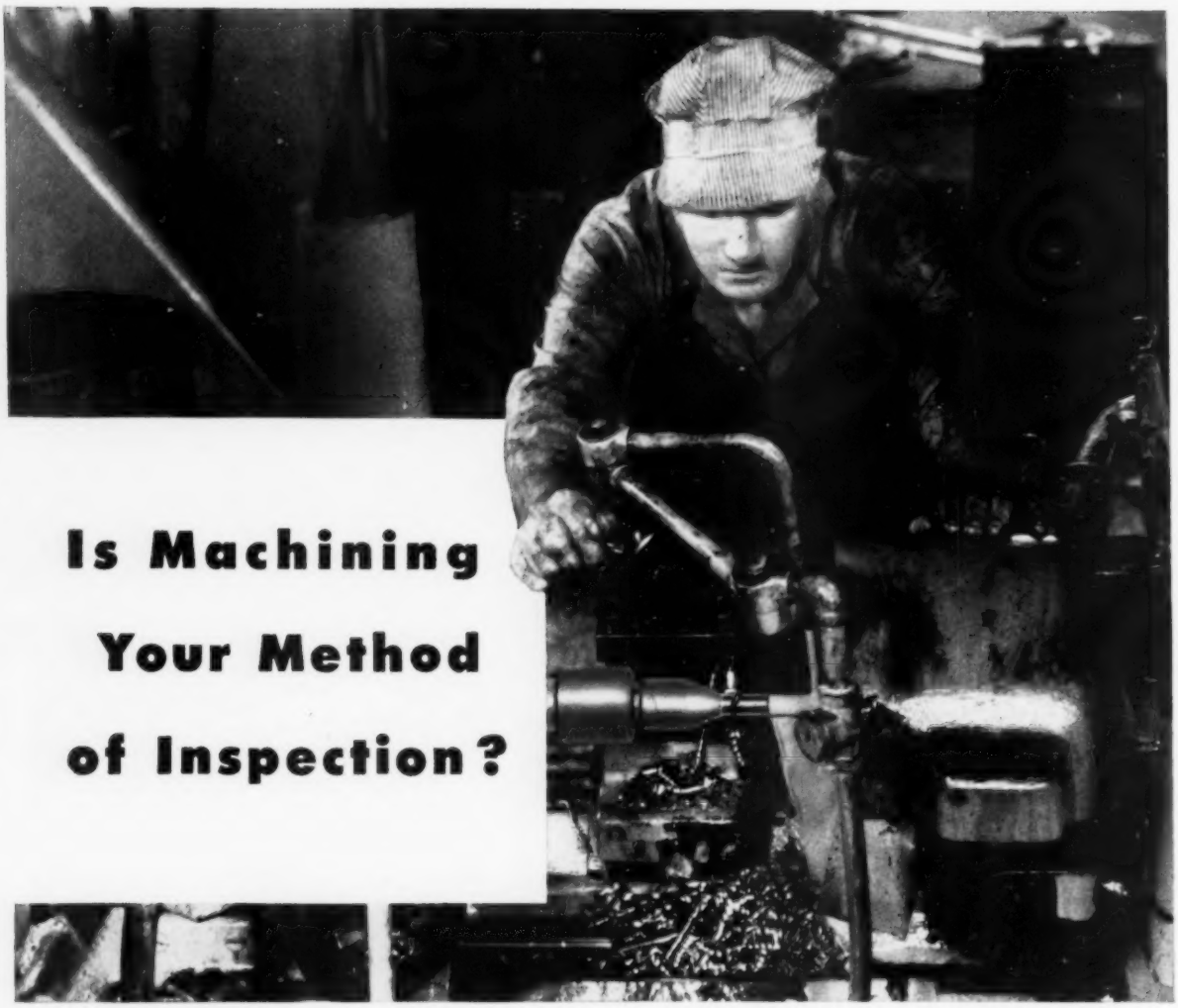

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IF YOU depend on machining to locate hidden defects in parts or material, you pay an exhorbitant price for "inspection"—through wasted labor and machine time. Further, there may be defects "getting by" that can later cost someone plenty in trouble and dollars.

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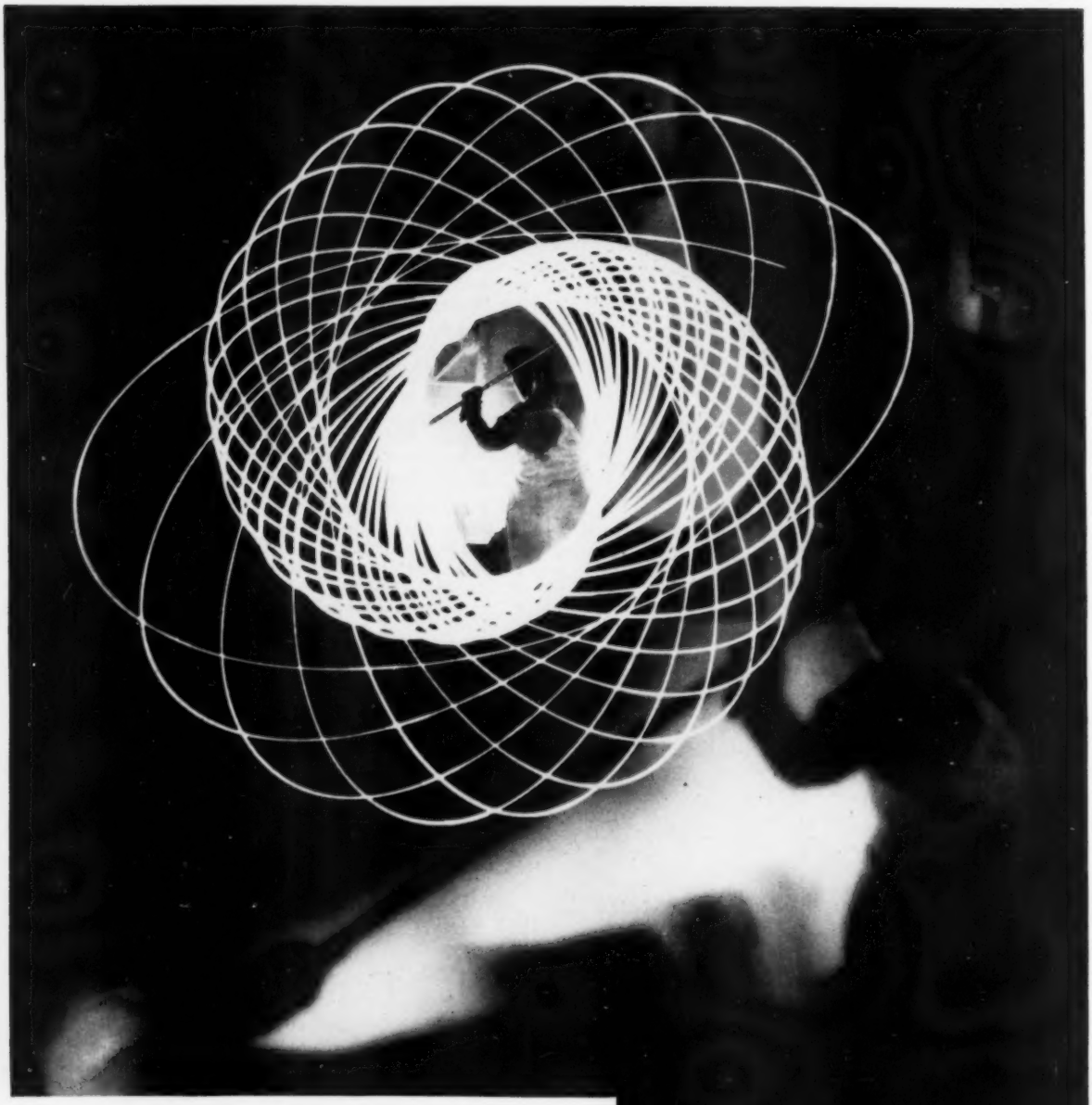

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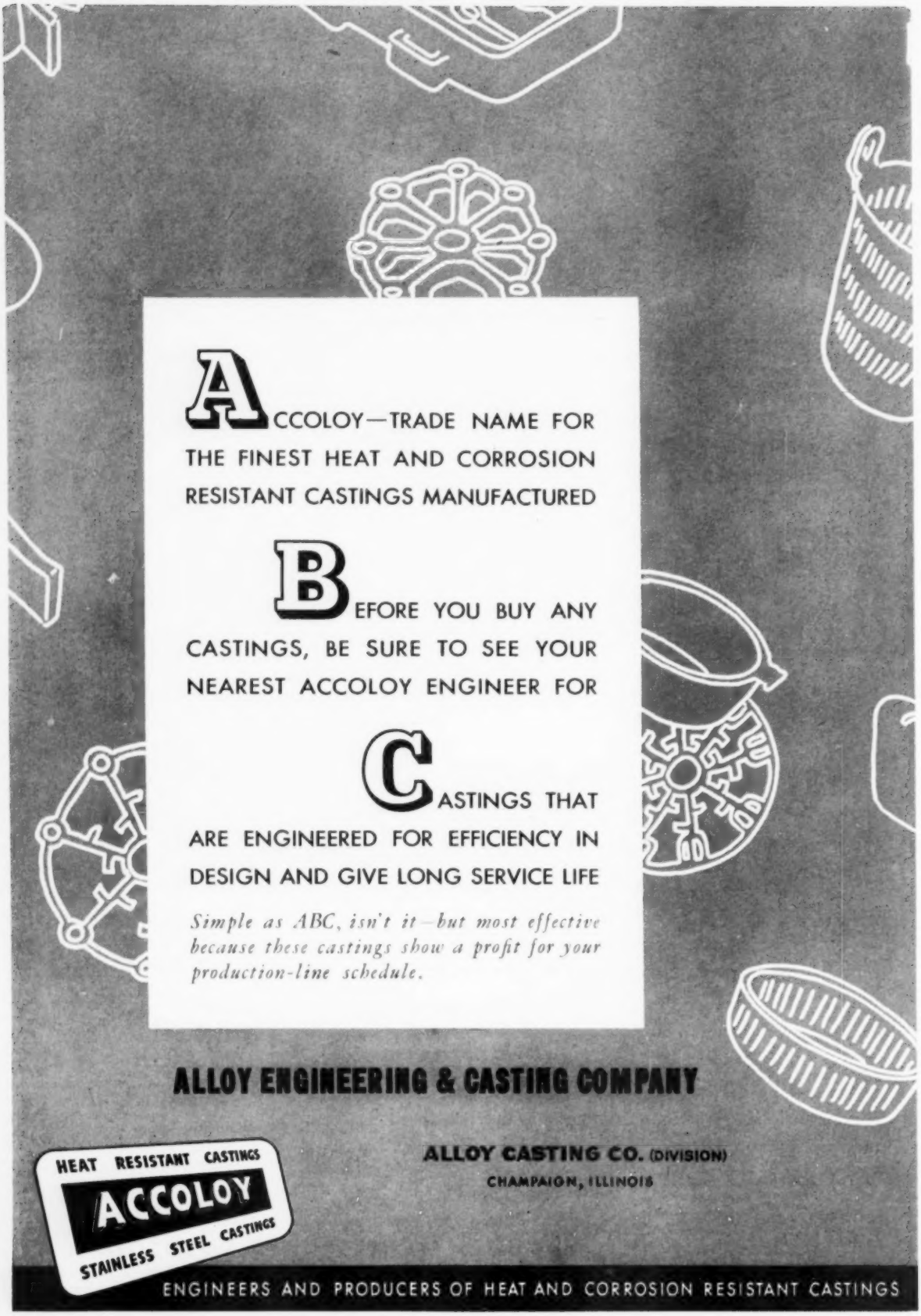
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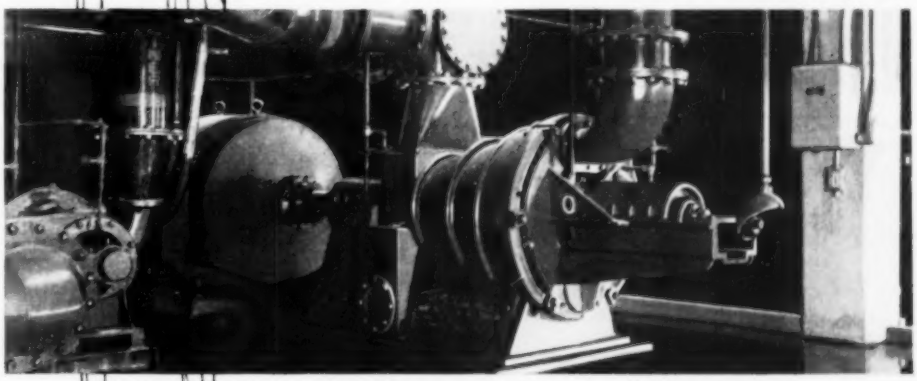

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Throat—4" deep. Gap—10" high. Weight—27 lbs.

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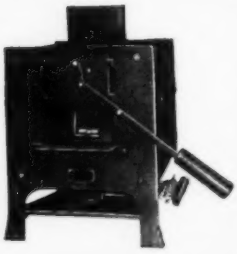

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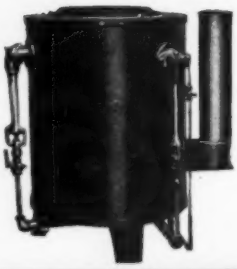

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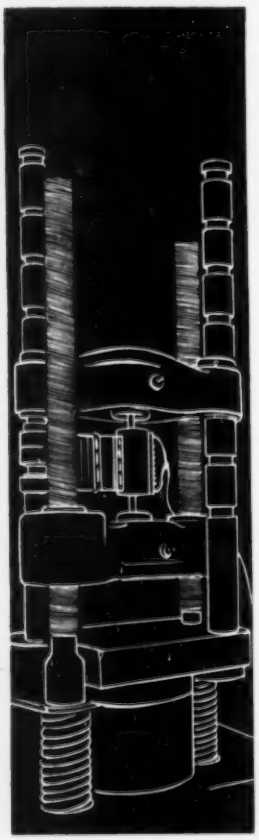

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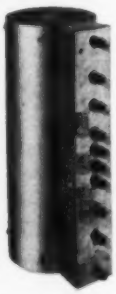

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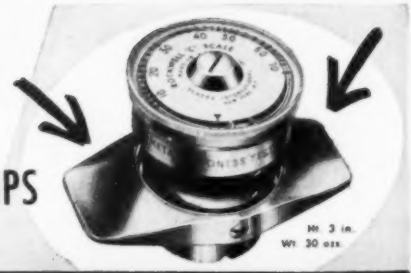

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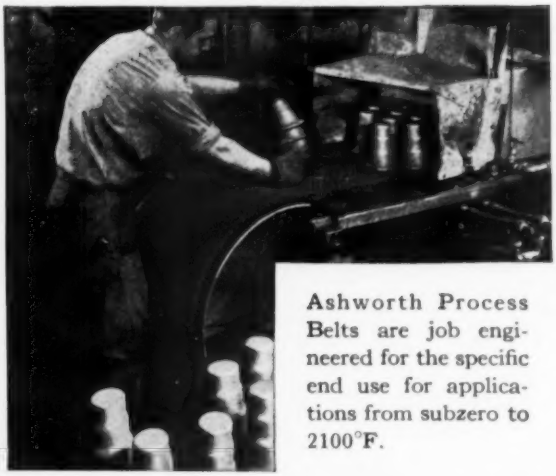

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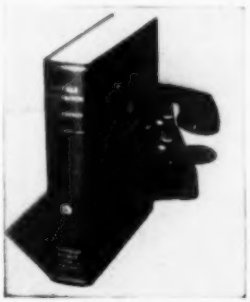

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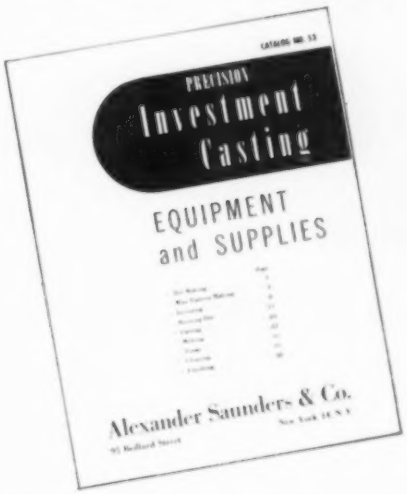

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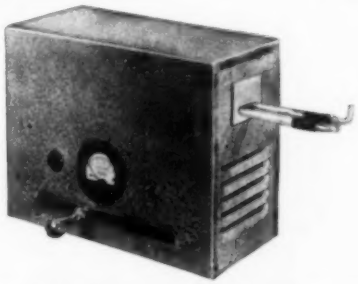

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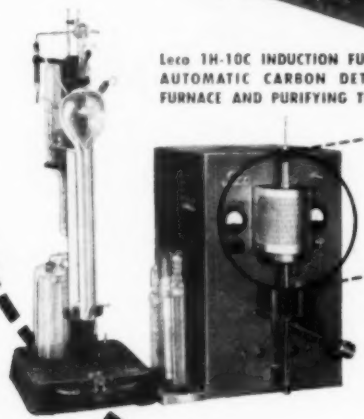

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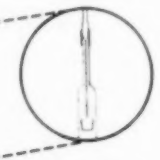

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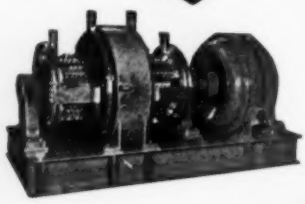

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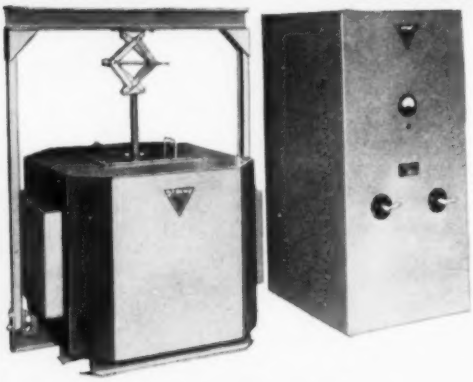

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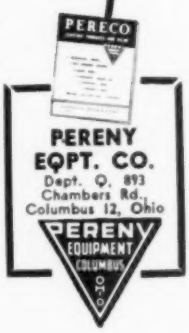

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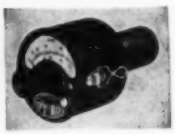

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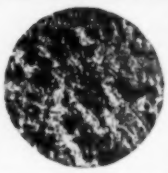	

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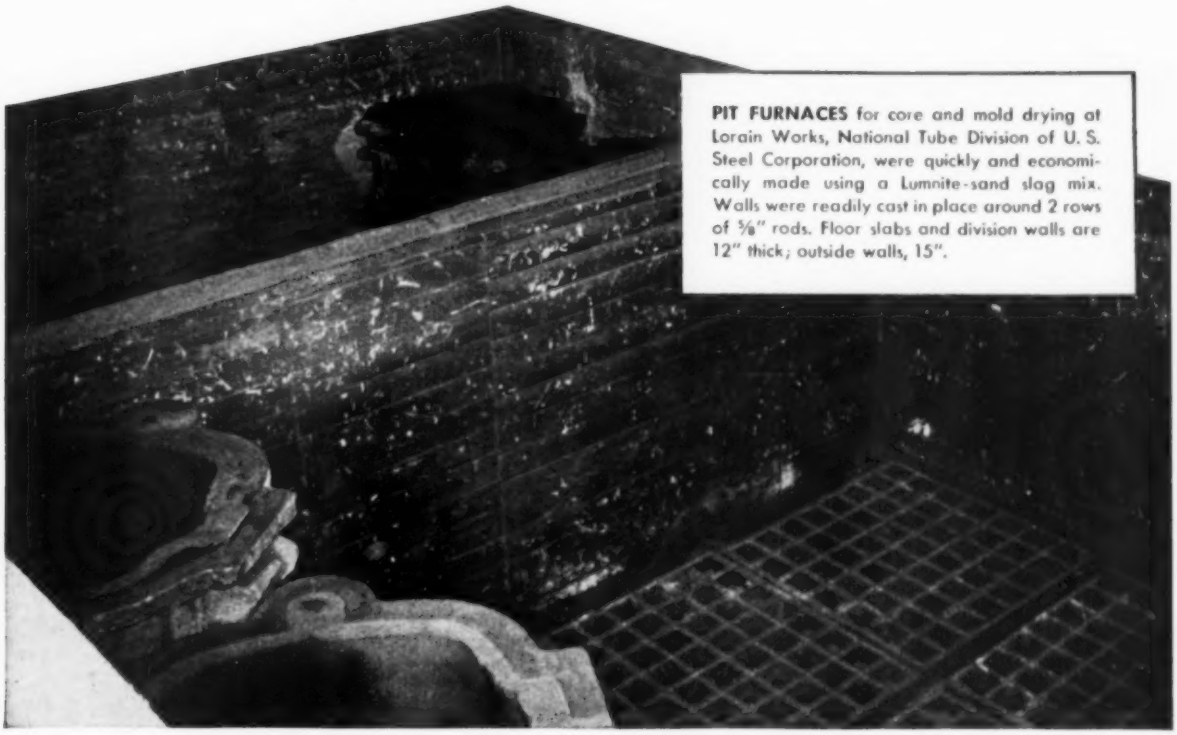

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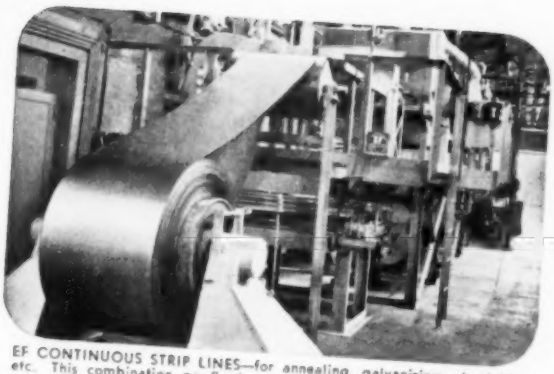
• Index to Advertisers •

Acheson Colloids Corp. 121
Air Reduction Sales Co. 199
Ajax Electric Co. 61
Ajax Electrothermic Corp. 45
Ajax Engineering Corp. 51
Aldridge Industrial Oils, Inc. 150, 155
Allegheny Ludlum Steel Corp. 36
Allied Research Products, Inc. 172
Alloy Engineering & Casting Co. 206
Alloy Precision Castings Co. 26
Almco Div. 146
American Brake Shoe Co. 43
American Brass Co. 117
American Chain & Cable
Wilson Mechanical Instrument Div. 170
American Chemical Paint Co. 122
American Gas Association 111
American Gas Furnace Co. 212
American Machine & Metals, Inc. 8
American Non-Gran Bronze Co. 214
American Rack Co. 148
American Roller Die Corp. 153
American Smelting & Refining Co. 197
American Society for Metals 207, 213
American Standards Testing Bureau, Inc. 156
Applied Research Laboratories 32
Archer Inc., Fred C. 62
Ashworth Brothers, Inc. 212
Atlantic Chemicals & Metals Co. 155
Atlas Mineral Products Co. 138
Baldwin-Lima-Hamilton Corp. 48
Bausch & Lomb Optical Co. 96D
Bell & Gossett Co. 144B
Bellevue Industrial Furnace Co. 178
Bellis Co. 151
Beryllium Corp. 58
Bethlehem Steel Co. 139, 208
Boder Scientific Co. 155
Branson Instruments, Inc. 157
Bristol Co. 17
Buehler Ltd. 56
Bundy Tubing Co. 160
Cambridge Wire Cloth Co. 166
Carborundum Co. 30, 177
Carl-Mayer Corp. 182
Carlson, Inc., G. O. 110
Carpenter Steel Co. 196
Chase Brass & Copper Co. 52
Chemical Corp., The 192
Chemineer, Inc. 148
Chicago Steel Foundry Co. 212
Cities Service Oil Co. 135
Clark Instrument Co. 190
Cleveland Crane & Engineering Co. 152
Cleveland Electric Laboratories Co. 149
Cleveland Metal Abrasive Co. 146
Climax Molybdenum Corp. 182
Cold Metal Products Co. 32B
Columbia Electric Mfg. Co. 214
Columbia Tool Steel Co. 180
Consolidated Vacuum Corp. 34
Cooley Electric Mfg. Corp. 150
Cooper Alloy Foundry Co. 209
Copperweld Steel Co. ..... Back Cover
Daniels Plating Barrel & Supply Co. 146
Deakin & Son, J. Arthur 155
Dempsey Industrial Furnace Corp. 149
Despatch Oven Co. 185
Detroit Testing Machine Co. 157, 178
Dow Chemical Co. 46
Drever Co. 127
Driver-Harris Co. 181
Du-Lite Chemical Corp. 147
duPont de Nemours & Co., Inc. 20
Eastman Kodak Co. 115
Eclipse Fuel Engineering Co. 211
Ekstrand & Tholand, Inc. 154
Electric Furnace Co. ..... Inside Back Cover
Electro Alloys Div. American Brake Shoe Co. 1
Electro Metallurgical Co.
Unit of Union Carbide and Carbon Corp. 107
Enthone, Inc. 179
Fahralloy Co. 54
Ferner Co., Inc. 180
Finkl & Sons Co., A. 12
Fisher Scientific Co. 96C
Gas Appliance Service, Inc. 130
General Alloys Co. 201
General Electric Co. 6-7
Gordon Co., Claud S. 188, 192
Great Lakes Carbon Corp. 28
Great Lakes Steel Corp. 53
Gulf Oil Corp. 136-137
Handy & Harman 187
Hangsterfer's Laboratories, Inc. 155
Hauck Mfg. Co. 21
Hayes, Inc., C. I. 189
Haynes Stellite Corp.
Unit of Union Carbide & Carbon Corp. 63
Hays Corp. 151
Hevi Duty Electric Co. 140, 141
Himmel Brothers Co. 154
Holcroft & Co. 32A
Holliday & Co., Inc., W. J. 194
Hones Inc., Chas. A. 210
Hooker Electrochemical Co. 125
Hoover Co. 154
Hoskins Mfg. Co. 169
Houghton & Co., E. F. 133
Illium Corp. 153
Imperial Plating Rack Co., Inc. 148
Industrial Heating Equipment Co. 149
Industrial Rack Co. 148
Insulation & Wires, Inc. 183
International Graphite & Electrode Div.
Speer Carbon Company 202
International Nickel Co. 41, 55, 96A
Ipsen Industries, Inc. 37
Jarrell-Ash Co. 211
Jelliff Mfg. Corp., C. O. 147
Jessop Steel Co. 144A
Jet Combustion, Inc. 116
Johns-Manville 40
Kemp Mfg. Co., W. H. 123
Kennametal, Inc. 128
Kent Cliff Laboratories 156
King Co., Andrew 210
L R Heat Treating Co. 11
Laboratory Equipment Corp. 213
Lakeside Steel Improvement Co. 151
LaSalle Steel Co. 39
Lavin & Sons, Inc. 195
Leeds & Northrup Co. 3, 198
Lindberg Engineering Co. 119
Lindberg Steel Treating Co. 152
Linde Air Products Co.
Unit of Union Carbide & Carbon Corp. 143
Little Falls Alloys, Inc. 154
Lord Chemical Co. 31
Lucas-Milhaupt Engineering Co. 157
Lumnite Division 215
Magnaflux Corp. 200
Magnetic Analysis Corp. 156
Mahon Co., R. C. 193
Malayan Tin Bureau 158
Manhattan Rubber Div.,
Raybestos-Manhattan, Inc. 146
Marshall Products Co. 210
Martindale Electric Co. 188
Maurath, Inc. 154
Meriam Instrument Co. 156
Merrill Bros. 144
Midland Industrial Finishes Co. 144
Midvale Co. 159
Milne & Co., A. 128B
Minnesota Mining & Mfg. Co. 13
Mitchell-Bradford Chemical Co. 118
Mueller Brass Co. 124
National Carbon Co.
Unit of Union Carbide & Carbon Corp. 33
National Rack Co., Inc. 148
Newage International, Inc. 211
Nitrogen Division
Allied Chemical & Dye Corp. 142
North American Mfg. Co. 22
Norton Co. 64
Olsen Testing Machine Co., Tinius 175
Oppiem Co. 184
Pangborn Corp. 186
Park Chemical Co. 59
Pennsylvania Salt Mfg. Co. 35
Pereny Equipment Co. 214
Peters-Dalton, Inc. 174
Peterson Steels, Inc. 163
Picker X-Ray Corp. 50
Pittsburgh Steel Co. 60
Pressed Steel Co. 109
Production Specialties, Inc. 155
Puritan Mfg. Co. 146
Pyrometer Instrument Co. 214
Pyrosil, Inc. 147
Ra-Diant Products Co. 150
Radio Corp. of America 165
Raybestos-Manhattan, Inc.
Manhattan Rubber Div. 146
Republic Steel Corp. 203
Revere Copper & Brass, Inc. 113
Reynolds Metals Co. 131
Richards Co., Inc., Arklay S. 151
Richards Co., J. A. 152
Rigidized Metals Corp. 153
Rockwell Co., W. S. 190
Roll Formed Products Co. 154
Rolock, Inc. 191
Ryerson & Son, Inc., Jos. T. 66
Sandvik Steel, Inc. 47
Sargeant & Wilbur, Inc. 134
Saunders & Co., Alexander 213
Sel-Rex Precious Metals, Inc. 147
Sentry Co. 168
Sherman Industrial Electronics Co. 149
Solar Steel Corp. 44
Sonken-Galamba Corp. 184
Spencer Turbine Co. 2
Sperry Products, Inc. 126
Standard Steel Treating Co. 151
Stanwood Corp. 150
Star Stainless Screw Co. 153
Stokes Machine Co., F. J. 38
Sun Oil Co. 18-19
Superior Steel Corp. 128A
Surface Combustion Corp. ..... Inside Front Cover
Swift Industrial Chemical Co. 148
Sylvania Electric Products, Inc. 114
Thermo Electric Co., Inc. 42
Timken Roller Bearing Co. 10
Titanium Alloy Mfg. Co. 204
Topper Equipment Co. 147
Tour & Co., Inc., Sam 156
Turco Products, Inc. 24
Union Carbide & Carbon Corp. 33, 63, 107, 143
Unitcast Corp. 164
United Chromium, Inc. 49
United States Steel Corp. ..... 16A, B, C, D
Upton Electric Furnace Co. 148
Vacuum Metals, Inc. 205
Vanadium Corp. of America 129
Waltz Furnace Co. 176
Waukee Engineering Co. 29
Waukesha Foundry Co. 4
Webber Appliance Co. 27
West Instrument Corp. 157
Western Products, Inc. 150
Westinghouse Electric Corp. 14-15, 120, 171
Wheelco Instruments Div. Barber-Colman Co. 5
Wheelock, Lovejoy & Co., Inc. 132
White Metal Rolling & Stamping Corp. 154
Wilson Mechanical Instruments Div.
American Chain & Cable 170
Wisconsin Steel Co. 57
Wyman-Gordon Co. 173
Yoder Co., The 186
Young Brothers Co. 211
Youngstown Sheet & Tube Co. 167
Youngstown Welding & Engineering Co. 148
Ziv Steel & Wire Co. 16



EF CONTINUOUS STRIP LINES—for annealing, galvanizing, aluminizing, etc. This combination gas-fired and electric unit provides flexibility in controlled heating, soaking and cooling, for producing various surface and metallurgical conditions on ferrous and nonferrous strip. Built by The Electric Furnace Co., Salem, Ohio.

EF CONTINUOUS FURNACES are built in many sizes and types for processing wire, sheet, castings, stampings, strip, tubing and many other products. This EF gas-fired radiant tube special atmosphere furnace bright normalizes 3000 lbs. steel tubing per hour. Built by The Electric Furnace Co., Salem, Ohio.

EF builds Gas-Fired, Oil-Fired and Electric Furnaces for these and other heat treating operations

● EF engineers specialize in designing and building production furnaces — continuous and batch types — including roller hearth, roller rail, chain belt, wire belt, slot and tube conveyor types, reciprocating, rotary, car, bell, pit and other designs; complete with special atmosphere producers, and time and labor saving material handling equipment as required.

Reflecting more than 30 years of continuous research and experience, and outstanding engineering accomplishments, EF furnaces combine high heating efficiency, accurate automatically controlled cycles, and advanced designs that minimize maintenance, assure economy of operation, high hourly output and uniformity of product.

Submit your production furnace problems to ***experienced engineers — it pays.***

THE ELECTRIC FURNACE CO.
GAS FIRED, OIL FIRED AND ELECTRIC FURNACES FOR ANY PROCESS, PRODUCT OR PRODUCTION
Salem - Ohio

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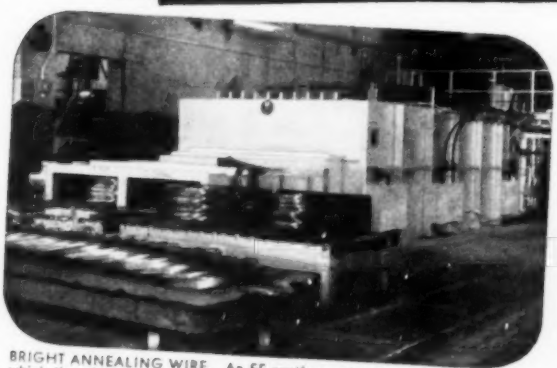
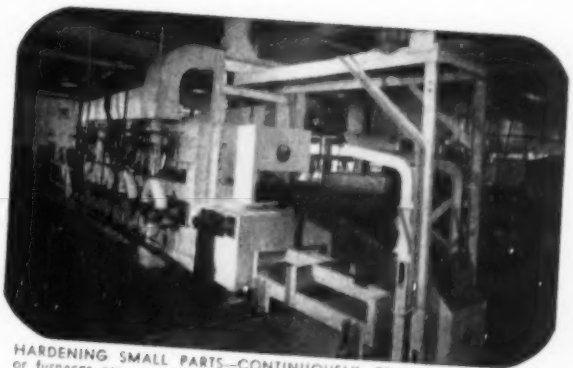
MALLEABLIZING
NORMALIZING
NITRIDING
SINTERING
SOLUTION TREATING
SPECIAL ATMOSPHERE TREATMENTS AND OTHER PROCESSES



BRIGHT ANNEALING WIRE. An EF continuous bright annealing furnace in which the wire is conveyed through the various zones on two parallel rows of bulkhead type trays. This unit has convection cooling and handles 2500 net lbs. of wire per hour. Built by The Electric Furnace Co., Salem, Ohio.



HARDENING SMALL PARTS—CONTINUOUSLY. EF chain belt conveyor furnaces are unsurpassed for uniform, low cost, scale-free hardening, carbon restoration and non-decarb heat treating. 11 sizes. Capacities from 175 to 2020 lbs. per hour. Built by The Electric Furnace Co., Salem, Ohio.

This Memo Concerns You

COPPERWELD STEEL COMPANY
WARREN, OHIO

ARISTOLOY STEELS

INTERIOR CORRESPONDENCE **DATE** July 29, 1953

FROM Executive Vice President **TO** General Manager-Sales

SUBJECT Steel Alloy Leaded

BOB:

We have begun operating our new installation for producing electric furnace carbon and alloy steel with lead under the Inland license.*

I believe it is now in order to let our customers know that Copperweld can furnish leaded steels so that they can take advantage of its economies such as improved machinability, improved production and longer tool life.

One of our friends called yesterday to say that their trial of leaded 4140 annealed showed a machinability rating of 100 compared to 60-70 for the same steel not lead treated. This result while probably better than can be hoped for in every instance indicates the potential value that most users can expect in improved production.

C.W.H.

Send a copy of this memo to our sales offices in:

New York
Chicago
Tulsa
Cleveland
Detroit
Los Angeles
Houston
Seattle
San Francisco
Syracuse

RSC.

* Inland Ledloy License